OXFORD MEDICAL PUBLICATIONS

A SYSTEM OF OPERATIVE SURGERY

OXFORD: HORACE HART
PRINTER TO THE UNIVERSITY

OXFORD MEDICAL PUBLICATIONS

A SYSTEM OF OPERATIVE SURGERY

BY VARIOUS AUTHORS

EDITED BY

F. F. BURGHARD, M.S. (LOND.), F.R.C.S. (ENG.)

TEACHER OF OPERATIVE SURGERY IN KING'S COLLEGE, LONDON
SURGEON TO KING'S COLLEGE HOSPITAL
SENIOR SURGEON TO THE CHILDREN'S HOSPITAL, PADDINGTON GREEN

IN FOUR VOLUMES

VOL. III

OPERATIONS UPON THE DUCTLESS GLANDS
OPERATIONS UPON THE BILE PASSAGES AND THE PANCREAS
OPERATIONS UPON THE CENTRAL NERVOUS SYSTEM
OPERATIONS UPON THE GENITO-URINARY ORGANS
OPERATIONS UPON THE THORAX AND ITS CONTENTS

LONDON
HENRY FROWDE, OXFORD UNIVERSITY PRESS
HODDER & STOUGHTON, WARWICK SQUARE, E.C.
1909

EDITOR'S PREFACE

GREAT as have been the advances made in Surgery during the last fifteen years, there is no direction in which they have been more noticeable than in the elaboration of those comparatively small but important details of operative technique which do so much to ensure a low mortality and a successful result.

These improvements have been developed simultaneously throughout the whole of the vast field covered by modern Surgery, and it has become increasingly difficult for any single writer to deal with such an important subject as Operative Surgery in an authoritative and efficient manner. The scope of the subject is so wide that it is difficult to ensure that the work when published shall be thoroughly up to date, while a second and even greater difficulty is for any one, however great his ability and experience, to deal equally exhaustively and authoritatively with all of the many branches of which he would have to treat.

To avoid both of these difficulties and thus to make sure that the work shall reflect faithfully the present position of British Operative Surgery, the plan has been adopted of securing the co-operation of a number of prominent British Surgeons. Each writer deals with a branch of the subject in which he has had special experience, and upon which, therefore, he is entitled to speak with authority.

Besides the two important points just referred to, a third equally important one has been kept in view throughout. Particular care has been taken to make the work of as much practical utility to the reader as possible. Not only are the various operations described in the fullest detail and with special

reference to the difficulties and dangers and the best methods of overcoming and avoiding them, but the indications for the individual operations are described at length, and the after-treatment and results receive adequate notice.

It is therefore hoped that the work will be useful alike to those who are about to operate for the first time, and to those surgeons of experience who desire to keep themselves informed as to the progress that has been made in the various branches of Operative Surgery.

The division of the work into a number of sections each written by a different author, necessarily involves some overlapping of subjects and some diversity of opinion upon points of technique. Efforts have been made to prevent overlapping of subjects as far as possible by care in their distribution and by conference between the authors concerned, but no attempt has been made to harmonize conflicting views. Each author supports his individual opinions by the weight of his authority, and any discrepancies may be taken to represent the absence of unanimity on various minor points that is well known to exist among surgeons of all countries.

The task of editing a work contributed to by so many writers might well appear to be an onerous one, but, owing to the promptitude, courtesy, and forbearance of all concerned, it has been a source of great pleasure, and the Editor's most cordial thanks are tendered to all those who have devoted so much time and trouble to the work.

PREFACE TO VOLUME III

THE illustrations appearing in this volume are, with few exceptions, original, and have been prepared by the artists direct from preparations, specimens, or original sketches. In preparing the illustrations for Dr. Newman's article, Mr. Maxwell, the artist, has been helped by some of those appearing in Sir Henry Morris's well-known treatise upon the Kidney and the Ureter. Professor J. Albarran has kindly allowed Mr. Thomson Walker to copy three illustrations (Figs. 247–9) appearing in his work.

Mr. J. H. Montague, Messrs. Weiss, Messrs. Mayer and Meltzer, and Messrs. Down Bros. have been good enough to supply a number of blocks illustrating surgical instruments.

September, 1909.

CONTRIBUTORS TO THIS VOLUME

HAROLD J. STILES, M.B., F.R.C.S. (Edin.)
Surgeon to Chalmers Hospital, Edinburgh, and to the Royal Hospital for Sick Children, Edinburgh

Operations for Tuberculous Disease of the Lymphatic Glands

Operations upon the Breast

B. G. A. MOYNIHAN, M.S. (Lond.), F.R.C.S. (Eng.)
Surgeon to the Leeds General Infirmary

AND

HAROLD UPCOTT, F.R.C.S. (Eng.)
Assistant Surgeon to the Hull Royal Infirmary

Operations upon the Spleen

JAMES BERRY, B.S. (Lond.), F.R.C.S. (Eng.)
Senior Surgeon to the Royal Free Hospital; Surgeon to the Alexandra Hospital for Children with Hip-disease

Operations upon the Thyreoid Gland

A. W. MAYO ROBSON, D.Sc., F.R.C.S. (Eng.)
Consulting Surgeon, Leeds General Infirmary

Operations upon the Bile Passages and the Pancreas

L. BATHE RAWLING, M.B., B.C. (Cantab.), F.R.C.S. (Eng.)
Assistant Surgeon to St. Bartholomew's Hospital

Operations upon the Skull and Brain

W. THORBURN, F.R.C.S. (Eng.)
Surgeon to the Manchester Royal Infirmary

Operations upon the Spinal Cord and Canal

DAVID NEWMAN, M.D. (Glasg.)

Surgeon to the Glasgow Royal Infirmary

Operations upon the Kidneys and Ureters

J. W. THOMSON WALKER, M.B., C.M. (Edin.), F.R.C.S. (Eng.)

Assistant Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

Operations upon the Bladder and the Urethra

P. J. FREYER, M.D., M.Ch. (R.U.I.)

Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

Operations for Vesical Calculus
Operations upon the Prostate

F. F. BURGHARD, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to King's College Hospital; Senior Surgeon to the Children's Hospital, Paddington Green

Operations upon the Male Genital Organs

RICKMAN J. GODLEE, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to University College Hospital; Consulting Surgeon to the Hospital for Consumption, Brompton

Operations upon the Thoracic Wall and its Contents

CONTENTS

SECTION I

OPERATIONS UPON THE DUCTLESS GLANDS

PART I

OPERATIONS FOR TUBERCULOUS DISEASE OF THE LYMPHATIC GLANDS

By HAROLD J. STILES, M.B., F.R.C.S. (Edin.)

Surgeon to Chalmers Hospital, Edinburgh, and to the Royal Hospital for Sick Children, Edinburgh

CHAPTER I

OPERATIONS FOR THE REMOVAL OF TUBERCULOUS CERVICAL GLANDS

CHAPTER II

COMPLICATIONS OCCURRING DURING OPERATIONS UPON TUBERCULOUS CERVICAL GLANDS: RESULTS

CHAPTER III

OPERATIONS FOR THE REMOVAL OF TUBERCULOUS GLANDS FROM THE AXILLA AND THE GROIN

PART II

OPERATIONS UPON THE SPLEEN

By B. G. A. MOYNIHAN, M.S. (Lond.), F.R.C.S. (Eng.)
Surgeon to the Leeds General Infirmary
and
HAROLD UPCOTT, F.R.C.S. (Eng.)
Assistant Surgeon to the Hull Royal Infirmary

CHAPTER IV

OPERATIONS UPON THE SPLEEN

PART III

OPERATIONS UPON THE THYREOID GLAND

By JAMES BERRY, B.S. (Lond.), F.R.C.S. (Eng.)
Senior Surgeon to the Royal Free Hospital; Surgeon to the Alexandra Hospital for Children with Hip-disease.

CHAPTER V

PUNCTURE: INJECTION: INCISION: LIGATURE OF THE THYREOID ARTERIES: EXOTHYREOPEXY

CHAPTER VI

OPERATIONS FOR REMOVAL OF A PORTION OF THE THYREOID GLAND

CHAPTER VII

REMOVAL OF THYREO-GLOSSAL AND BRANCHIAL CYSTS AND FISTULÆ

SECTION II

OPERATIONS UPON THE BILE PASSAGES AND THE PANCREAS

By A. W. MAYO ROBSON, D.Sc., F.R.C.S. (Eng.)
Consulting Surgeon, Leeds General Infirmary.

CHAPTER I

THE SURGICAL ANATOMY OF THE BILE PASSAGES: GENERAL REMARKS: OPERATIONS FOR INJURY TO THE BILE DUCTS

CHAPTER II

OPERATIONS UPON THE GALL-BLADDER

CHAPTER III

OPERATIONS UPON THE BILE DUCTS

CHAPTER IV

OPERATIONS UPON THE PANCREAS

SECTION III

OPERATIONS UPON THE CENTRAL NERVOUS SYSTEM

PART I

OPERATIONS UPON THE SKULL AND BRAIN

By L. BATHE RAWLING, M.B., B.C. (Cantab.), F.R.C.S. (Eng.)
Assistant Surgeon to St. Bartholomew's Hospital.

CHAPTER I

CRANIO-CEREBRAL TOPOGRAPHY

CHAPTER II

THE SPECIAL TECHNIQUE OF OPERATIONS UPON THE SKULL AND BRAIN

CHAPTER III

OPERATIONS FOR FRACTURES OF THE SKULL

CHAPTER IV

OPERATIONS FOR INTRACRANIAL HÆMORRHAGE

CHAPTER V

OPERATIONS FOR BULLET-WOUNDS OF THE SKULL AND BRAIN

CHAPTER VI

OPERATIONS FOR TRAUMATIC EPILEPSY AND INSANITY: CLOSURE OF DEFECTS IN THE SKULL

CHAPTER VII

OPERATIONS FOR INTRACRANIAL SUPPURATION

CHAPTER VIII

OPERATIONS FOR TUMOURS OF THE BRAIN

CHAPTER IX

OPERATIONS FOR HYDROCEPHALUS INTERNUS: OPERATIONS FOR CEPHALOCELES

PART II

OPERATIONS UPON THE SPINAL CORD AND CANAL

By W. THORBURN, F.R.C.S. (Eng.)

Surgeon to the Manchester Royal Infirmary

CHAPTER X

OPERATIONS FOR SPINA BIFIDA

CHAPTER XI

LAMINECTOMY

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART I

OPERATIONS UPON THE KIDNEYS AND URETERS

By DAVID NEWMAN, M.D. (Glasg.)

Surgeon to the Glasgow Royal Infirmary.

CHAPTER I

THE REGIONAL ANATOMY OF THE KIDNEYS AND URETERS

CHAPTER II

METHOD OF PHYSICAL EXAMINATION APPLICABLE TO THE KIDNEYS AND URETERS

CHAPTER III

ASPIRATION, EXPLORATION, AND INCISION OF THE KIDNEY

CHAPTER IV

NEPHRO-LITHOTOMY

CHAPTER V

NEPHRECTOMY

CHAPTER VI

NEPHROPEXY

CHAPTER VII

OPERATIONS UPON THE URETERS

PART II

OPERATIONS UPON THE BLADDER

By J. W. THOMSON WALKER, M.B., C.M. (Edin.), F.R.C.S. (Eng.)

Assistant Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases.

CHAPTER VIII

CYSTOTOMY

CHAPTER IX

OPERATIONS FOR TUMOURS OF THE BLADDER

CHAPTER X

CYSTECTOMY

CHAPTER XI

OPERATIONS FOR ECTOPIA VESICÆ

CHAPTER XII

OPERATIONS FOR THE REPAIR OF VESICO-VAGINAL FISTULÆ

PART III

OPERATIONS FOR VESICAL CALCULUS

By P. J. FREYER, M.D., M.Ch. (R.U.I.)

Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases.

CHAPTER XIII

LITHOLAPAXY

CHAPTER XIV

LITHOTOMY

PART IV

OPERATIONS UPON THE PROSTATE

By P. J. FREYER, M.D., M.Ch. (R.U.I.)

Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases.

CHAPTER XV

SUPRAPUBIC PROSTATECTOMY

CHAPTER XVI

PERINEAL PROSTATECTOMY: OPENING A PROSTATIC ABSCESS

PART V

OPERATIONS UPON THE URETHRA

By J. W. THOMSON WALKER, M.B., C.M. (Edin.), F.R.C.S. (Eng.)

Assistant Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases.

CHAPTER XVII

URETHROSCOPY: OPERATIONS UPON THE URETHRAL MUCOUS MEMBRANE: REMOVAL OF URETHRAL CALCULI

CHAPTER XVIII

OPERATIONS FOR INJURIES TO THE URETHRA

CHAPTER XIX

OPERATIONS FOR STRICTURE OF THE URETHRA

CHAPTER XX

OPERATIONS FOR THE REPAIR OF FISTULÆ AND ACQUIRED DEFECTS OF THE URETHRAL WALL

PART VI

OPERATIONS UPON THE MALE GENITAL ORGANS

By F. F. BURGHARD, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to King's College Hospital; Senior Surgeon to the Children's Hospital, Paddington Green.

CHAPTER XXI

OPERATIONS UPON THE PENIS

CHAPTER XXII

OPERATIONS UPON THE SCROTUM AND CORD

CHAPTER XXIII

OPERATIONS UPON THE TESTICLE

SECTION V

OPERATIONS UPON THE THORAX AND ITS CONTENTS

PART I

OPERATIONS UPON THE BREAST

By HAROLD J. STILES, M.B., F.R.C.S. (Edin.)

Surgeon to Chalmers Hospital, Edinburgh, and to the Royal Hospital for Sick Children, Edinburgh.

CHAPTER I

OPERATIONS UPON THE BREAST

PAGES

PART II

OPERATIONS UPON THE THORACIC WALL AND ITS CONTENTS

By RICKMAN J. GODLEE, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to University College Hospital; Consulting Surgeon to the Hospital for Consumption, Brompton.

CHAPTER II

OPERATIONS UPON THE THORACIC WALL AND THE MEDIASTINA

CHAPTER III

OPERATIONS FOR THE REMOVAL OF FLUIDS FROM THE PLEURAL CAVITIES

CHAPTER IV

OPERATIONS UPON THE LUNGS

CHAPTER V

OPERATIONS UPON THE PERICARDIUM, THE HEART, AND THE PULMONARY ARTERY

CHAPTER VI

OPERATIONS UPON THE DIAPHRAGM AND FOR SUBDIAPHRAGMATIC AND HEPATIC ABSCESS

LIST OF ILLUSTRATIONS

COLOURED PLATES

SECTION I

OPERATIONS UPON THE DUCTLESS GLANDS

PART I

OPERATIONS FOR TUBERCULOUS DISEASE OF THE LYMPHATIC GLANDS

BY

HAROLD J. STILES, M.B., F.R.C.S. (Edin.)

Surgeon to Chalmers Hospital, Edinburgh, and to the Royal Hospital for Sick Children, Edinburgh

CHAPTER I

OPERATIONS FOR THE REMOVAL OF TUBERCULOUS CERVICAL GLANDS

In performing operations for tuberculous disease of the cervical glands an intimate knowledge of the anatomy of the neck is all-important. If the operator knows exactly where to expect each anatomical structure before it is exposed, he will know when he may use the knife freely and when he must use it cautiously. When all the group of glands which go to form the deep cervical chain are involved the operation is necessarily a tedious and arduous one, and whether it occupies two hours or only one will depend very largely on the anatomical knowledge of the operator. Lack of this knowledge is often responsible for unnecessary injury to important structures, for recurrence—due to incomplete removal of the disease—in short, for bringing into discredit an operation which is performed too seldom rather than too frequently, and which, moreover, is often too long postponed. It must be remembered, too, that the disease is generally much more extensive than the clinical appearances might lead one to suppose. The operation is by no means of the minor nature which the patient is unfortunately often led to believe. Besides the glands which are visibly and palpably enlarged there are almost invariably others situated more deeply, which, although smaller, are nevertheless diseased.

SURGICAL ANATOMY

Before proceeding to describe the various operations for the removal of tuberculous cervical glands it will be necessary to refer shortly to the anatomy of the various groups of glands, and to their relations to the more important structures which have to be dealt with in the course of the operation. Each group receives its lymphatics from definite regions, and by noting the position of the glands first involved the peripheral source of infection can often be discovered. The spread of the disease from one glandular group to another is due to the fact that the efferent lymphatics from one group form part of the afferent vessels going to the group situated proximal to it; hence the disease may spread so as to involve the entire deep cervical chain.

The following short account of the topography of the glandular groups

and the areas which drain into them is founded mainly on the work of Delamere, Poirier, and Cunéo. According to these authors, the glands of the head and neck are arranged into two main systems; the one forms a circular chain at the junction of the head and neck, while the other consists of a right and left vertical chain, each of which descends under the sterno-mastoid and accompanies the internal jugular vein from the base of the skull to the root of the neck.

The pericervical glandular circle is made up of the following groups, placed in the following order from before backwards: the submental, the submaxillary, the parotid, the mastoid, and the occipital.

The *submental glands* lie on the mylo-hyoid muscle between the anterior bellies of the digastric muscles. Sometimes they lie nearer the jaw, at other times nearer the hyoid bone, and when in the latter situation they are referred to as the suprahyoid glands. They receive their lymphatics from the skin of the lower lip and chin, and from the mucous membrane of the tip of the tongue and the anterior part of the floor of the mouth. When tuberculous, they are rarely alone involved; more frequently they are diseased along with the submaxillary glands. Their efferent vessels drain into the anterior group of the upper deep cervical glands on both sides of the neck; hence it is not uncommon to find the glands in both carotid triangles diseased secondary to the submental glands.

The *submaxillary glands* are confined to the digastric triangle. Like the preceding group they lie beneath the general envelope of cervical fascia. Those in front and behind the submaxillary gland are tucked up under cover of the mandible, the posterior set being closely related to the facial artery and to the junction of the facial with the anterior division of the temporo-maxillary (posterior facial) vein. For practical purposes, we must consider, along with the submaxillary group, the gland which lies on the outer aspect of the mandible in close contact with the facial artery. The submaxillary glands receive their afferent vessels from the anterior part of the face including the inner half of the conjunctiva and orbit, from the nose, from the mucous membrane of the mouth including the teeth and gums, and from the anterior part of the tongue. The efferent vessels drain into the same glands as the submental.

Of the *parotid lymphatic glands* one or two (preauricular) lie just in front of the tragus, immediately beneath the parotid fascia. A number of others are scattered through the substance of the gland; they are separated from the submaxillary lymphatic glands by the stylo-maxillary ligament. Along with these intraparotid glands are to be included a small group known as the *superficial cervical* or *subauricular glands.* These form a short chain which lies along the anterior border of the sterno-mastoid in contact with the commencement of the external jugular vein;

when enlarged they form a swelling immediately below the auricle and fill up the space between the jaw and the mastoid process (see Fig. 1, A). The parotid lymphatic glands receive their efferent lymphatics from the

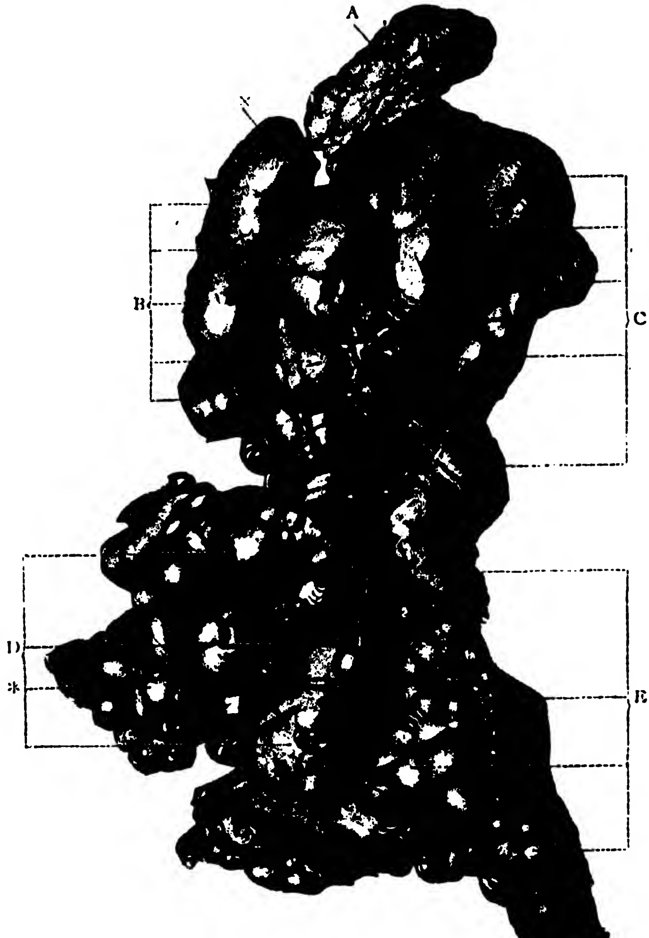


FIG. 1. TUBERCULOUS GLANDS REMOVED FROM THE LEFT SIDE OF THE NECK OF A FEMALE AGED TWENTY-THREE. The mass was excised through two oblique incisions, an upper and a lower. A similar mass was removed from the right side of the neck by the J-shaped incision shown in Fig. 4. A, The superficial cervical (subauricular) group; B, The upper anterior group, the gland indicated by the × being the tonsillar lymphatic gland; C, The upper posterior group; D, The lower anterior group; the subsidiary cluster indicated by the * lay in front of the vertebral vein in close relation to the thoracic duct, from which it was separated; E, The lower posterior (supraclavicular) group, the tail-like postero-inferior projection of which dipped under the trapezius and clavicle and lay upon the upper digitation of the serratus magnus.

outer and middle ear; from the skin of the frontal, parietal, and temporal regions; from the eyelids, and probably also from the nasal fossæ. Their efferent vessels descend to the deep cervical glands. When the superficial and deep parotid glands are the first group to become tuberculous, the primary source of infection will generally be found to be in the middle ear. The anatomical structures of importance which have to be dealt with in removing the parotid lymphatic glands are: the facial nerve, especially its cervico-facial division, the temporo-maxillary (posterior facial) and external jugular veins, and the external carotid artery; the latter can generally be avoided, but the veins, which are more superficial, must be divided.

The *mastoid and suboccipital glands* need not be specially referred to, as they are comparatively rarely tuberculous.

By the term *deep cervical glands* is included a broad chain of lymph nodes which is closely related to the internal jugular vein, and which stretches from the transverse process of the atlas to the root of the neck. The chain is in reality made up of subsidiary glandular groups, each of which receives its lymphatics from fairly well-defined areas. As already mentioned, the different groups are connected to one another by intervening lymphatic vessels.

In the first place, the chain may be divided into an upper and a lower portion, the former situated above the level of the anterior belly of the omo-hyoid muscle, the latter below it. Each of these divisions is again subdivided into an anterior and a posterior chain.

Of the four groups, the *upper anterior* (see Fig. 1, B) is the most important, as it is here that the disease first manifests itself in the vast majority of cases. The reason for this predilection is due to the fact that this group of glands, in addition to receiving efferent lymphatics from the glands of the circular chain, receives also lymphatics directly from the naso-pharynx, including the faucial and pharyngeal tonsils—structures which are now known to provide the chief portals of entrance through which the tubercle bacilli reach the efferent lymphatics. Wood, of Philadelphia, has succeeded in tracing the lymphatics from the tonsils directly into one of the glands of this group, namely, that situated a little below the angle of the jaw, under cover of the anterior border of the sterno-mastoid immediately below the posterior belly of the digastric. The relations of the deep surface of this gland are important. It lies upon the anterior surface of the internal jugular, in the angle between it and the common facial vein. It plays such an important rôle in tuberculous adenitis that Wood has, very properly, suggested that it should be specified as the tonsillar lymphatic gland. In the great majority of cases it is the first gland in the neck to

show signs of tuberculous enlargement. With the assistance of Mr. Scott Carmichael, the writer has removed and examined the tonsils in fifty consecutive cases in which this gland was tuberculous. Distinct histological evidence of tubercle was found in seven out of the fifty cases (14%).

When the upper anterior deep cervical glands become enlarged they form a swelling which projects from beneath the sterno-mastoid forwards into the carotid division of the anterior triangle. The mass soon becomes adherent to the general envelope of deep cervical fascia, and if the disease be allowed to run its course the latter becomes perforated, with the result that a subcutaneous tuberculous abscess soon develops. By excising the glands before they become adherent to the fascia, not only are they easily shelled out, but the fascia itself may be preserved and sutured so as to prevent stretching of the cicatrix. The glands are also liable to become adherent to the digastric muscle and to the stylo-maxillary ligament; the latter structure separates them from the submaxillary lymphatic glands. The most important adhesions, however, from the operator's point of view, are to the common facial and internal jugular veins.

Below the tonsillar lymphatic gland the infection generally tapers off by the development of a few small tuberculous glands which extend down the antero-external aspect of the internal jugular, as far as where it is crossed by the omo-hyoid muscle. While the majority of these glands are situated outside the carotid sheath, one or two are not infrequently found between the sheath and the wall of the vein. The carotid sheath is not always such a definite structure as the anatomical textbooks would lead us to suppose.

The *upper posterior* group (see Fig. 1, C) of deep cervical glands lies postero-external to the internal jugular upon the origins of the splenius and the levator anguli scapulæ muscles. They are smaller in size than the anterior group, but when enlarged they may form a swelling which projects across the posterior triangle as far as the trapezius. They are embedded in a quantity of fibro-fatty tissue which supports the spinal accessory nerve and the cervical plexus. When these glands are tuberculous the spinal accessory nerve lies either superficial to the mass or more frequently traverses it. Wood has succeeded in demonstrating that the lymphatics from the pharyngeal tonsil, after piercing the posterior wall of the pharynx, pass downwards and outwards behind the sheath of the great vessels to enter the glands situated deeply, just below the tip of the mastoid process. This important anatomical fact serves to explain how it is that these glands are so frequently involved along with the upper anterior group.

In aggravated cases of tuberculous cervical adenitis, the infection spreads downwards as far as the root of the neck so as to involve both

lower groups of the chain. The *lower anterior group* (see Fig. 1, D) forms a somewhat narrow chain which is continued down the outer aspect of the internal jugular as far as its junction with the subclavian. Above the level of the omo-hyoid this chain is continuous with the upper anterior jugular group, while below it comes into relation with the superior mediastinal glands. External to the jugular these glands lie upon the scalenus anticus (anterior) and the phrenic nerve. When diseased, the upper as well as the lower internal group of the deep cervical chain dip between the internal jugular and the prevertebral fascia, and when this occurs to an unusual degree the internal jugular vein may be pushed forward so as to occupy a much more superficial position than normal. Although the glands which form this lower internal group receive lymphatics directly from the larynx, trachea, œsophagus, and thyreoid gland, they are much more frequently infected by extension of the disease from the glands above rather than secondarily to the organs above mentioned.

The *lower posterior* group (see Fig. 1, E) of deep cervical glands are continuous above with the upper-posterior group. Like the upper posterior group, they lie altogether behind the internal jugular vein, upon the levator anguli scapulæ, the scalenus medius, and the brachial plexus. The lowest glands of the group, viz. the supraclavicular, are subdivided into a superficial and deep cluster by the omo-hyoid muscle and the middle layer of deep cervical fascia.

GENERAL CONSIDERATIONS IN THE TECHNIQUE

Before describing the technique of the individual operations for the removal of tuberculous cervical glands it may be well to draw attention in the first place to certain general considerations.

The *skin incision* should not be unnecessarily long, but at the same time it should be long enough to give proper access to the disease. Suitable retractors should be freely used; it is therefore an advantage to have a third assistant.

As far as possible the incisions should be made parallel to the natural creases and lines of cleavage of the skin, as the cicatrices which result from them show little or no tendency to stretch, whereas those placed vertically are very liable to do so. If it be necessary to make a vertical incision it should be kept as far back as possible. The deep fascia should not be removed if it can be avoided; by suturing it either independently with catgut, or along with the skin and platysma, it helps to prevent broadening of the cicatrix.

When the glands form a continuous chain or a nodular cluster, *they*

should be removed as far as possible en masse. The knife should be carried well down on to the glands, and in dissecting them out it should be kept close to them. When loose connective tissue intervenes between the glands and the surrounding structures, blunt dissection may be employed. This may be carried out either with the finger, with gauze, or by the aid of special instruments, such as Kocher's 'Kropfsonde' and C. H. Mayo's dissecting scissors. The handle of the knife is rather a clumsy instrument for the purpose. If Cheyne's dissector be employed it should be made with the curved end set back so that its extremity is in a line with the handle. When, however, the glands are more or less fixed and adherent they can be removed much more rapidly and safely by clean dissection with a well-sharpened knife, the edge of which should be kept directed towards the glands. The more experienced the operator, the less will he have recourse to blunt dissection. The writer would caution the inexperienced operator against drawing forward the glands and cutting blindly behind them with blunt-pointed scissors; by this procedure either the common facial vein or the internal jugular is very liable to be injured.

The forceps which are used for application to the glands during the dissection should possess toothed extremities. The writer prefers those introduced by Mr. Leedham Green. When it is necessary to make more traction on the glands the operator may use Kocher's toothed artery forceps or one of the various forms of tissue-grip forceps. Fenestrated forceps, specially made for the purpose, are sometimes helpful, but when the glands are caseous they are very liable to be ruptured.

The assistant should *keep the wound as dry as possible* during the course of the operation, as it is important that the operator should see exactly what he is doing. The bleeding is distinctly less under chloroform anæsthesia than under ether, but unfortunately toxic after-effects are much more liable to occur after the use of the former drug. If ether be used the head and shoulders should be elevated so as to prevent venous engorgement. With chloroform, on the other hand, the patient may be kept horizontal, with the field of operation opened out by allowing the head to fall back over a small sand-bag placed behind the neck.

Drainage. The cervical glands cannot be removed without the division of many of the main lymphatic vessels of the neck. Hence a considerable quantity of lymph is mixed with the blood-stained exudate; indeed, it occasionally happens that the former is so abundant as to amount almost to lymphorrhœa. It is advisable, therefore, to leave the drainage tube in position for three days. Except when the wound is in the posterior triangle, it is generally better to bring the tube out through a special

opening behind the sterno-mastoid rather than at the main wound, and it is advisable to stitch the tube to the skin rather than to transfix it with a safety-pin—the latter prevents the tube from slipping into the wound, but it does not prevent it from slipping out. The length and direction of the tube should be so arranged that it does not press on the internal jugular vein. Instead of a rubber tube some surgeons prefer to use a cigarette drain of gutta-percha tissue, or several strands of silkworm-gut.

Closure of the wound. The suturing of the wound is a very important part of the operation, especially from the patient's point of view, as the cosmetic result depends a good deal on the care with which it is done. To avoid the scars of the needle-punctures, some surgeons prefer to close the wound by means of a subcuticular suture, but if horsehair (or fine silkworm-gut) be used, and introduced with a fine needle, the cicatrices left by the skin-punctures become practically invisible. The writer prefers interrupted sutures to a continuous one, as the depth of the former can be varied more easily, and, moreover, they allow a certain amount of blood-stained serum to escape between them. The deep fascia may be brought together separately with catgut, or it may be sutured with silkworm-gut along with the skin and platysma. Superficial horsehair sutures are introduced between the main sutures so as to bring about very accurate apposition of the skin edges and prevent their inversion by the platysma. The disadvantage of applying a continuous suture while the edges of the wound are put on the stretch by a hook introduced at each extremity is, that when the hooks are removed the wound shortens, with the result that the stitch is slackened and the skin edges are very liable to become inverted. It is important to see that the head is brought into the natural position while the wound is being closed, otherwise its edges will not fit accurately.

The dressing. In dressing the wound an abundance of sterilized gauze should be used, partly on account of the copious wound exudate, and partly with the object of allowing the bandage to be firmly applied. Moreover, the dressing should extend far beyond the wound in all directions, and the bandage should include the chest as well as the head and neck. When the wound involves, or extends down to, the root of the neck, care should be taken to see that the front and back of the shoulder are well covered.

After-treatment. As regards the after-treatment, it is well to keep the patient recumbent for a few days with the head and shoulders slightly elevated. There is often some pain on swallowing for a day or two, and during this time solid food may have to be withheld. As a rule, it is better not to remove the stitches until the seventh day, and after doing so collodion may be applied to prevent the cicatrix from stretching.

EXCISION OF THE ANTERIOR GROUP OF UPPER DEEP CERVICAL GLANDS

This may be regarded as the typical operation for the early stage of disease of the deep cervical glands. The incision (see Fig. 2, B) extends in a line from the tip of the mastoid process either to the hyoid bone or the pomum Adami, depending on the extent to which the disease has extended downwards along the internal jugular vein. The advantage of this incision over one parallel to the anterior border of the sterno-mastoid is that it lies parallel to the natural creases and lines of cleavage of the skin (Kocher); the resulting cicatrix, therefore, shows no tendency to stretch. The more the incision approaches the vertical the greater is its tendency to stretch. The length of the cicatrix should be proportional to the size of the glandular mass. The inexperienced operator generally adds to his difficulties by making the incision too small; it is only the more experienced who should try to reduce the incision to a minimum.

FIG. 2. INCISIONS FOR REMOVAL OF THE CERVICAL GLANDS. A, Incision for removal of the submaxillary glands; B, Incision for removal of the anterior group of the upper deep cervical glands; C, Incision when the disease in the lower part of the posterior triangle is very extensive; D, Incision for removal of the glands from the lower part of the posterior triangle in ordinary cases. The incision C or D may be used in conjunction with B when the entire vertical chain of deep cervical glands is involved.

The upper part of the external jugular vein and the great auricular nerve, which lies immediately behind it, are exposed at the upper end of the wound. The former is divided between forceps, and it may be necessary also to divide the nerve. In reflecting the flaps, the operator should keep close to the deep fascia so as to include the platysma and the whole thickness of the superficial fascia. The deep fascia is divided along the anterior border of the sterno-mastoid, and the latter is then freed and dissected backwards off the glands until the spinal accessory nerve is exposed. The nerve is accompanied by the superior sterno-mastoid artery, a branch of which is generally divided before the

nerve is actually exposed, so that the operator is warned of its close proximity. The nerve is freed by slitting up the fascia which forms the posterior layer of the sheath of the sterno-mastoid. The superficial aspect of the glandular mass is laid bare by dividing the cervical fascia which roofs over the carotid division of the anterior triangle in front of the sterno-mastoid. The glands are then seized with forceps and drawn forwards so as to facilitate their separation from the deeper structures. The best way to avoid injury to the common facial and internal jugular veins is to keep the edge of the knife directed towards the glands.

It is a matter of no great importance whether the glands be freed from above downwards or from below upwards. It will generally be found most convenient to begin the deeper part of the dissection at whichever edge of the mass is most accessible, as each structure exposed is a guide to the position of those adjacent to it. When the deep dissection is begun anteriorly, almost the first structure of importance which is encountered is the common facial vein, to which the tonsillar lymphatic gland is generally more or less adherent. At the upper part of the mass is the lower part of the parotid, the deep landmark being the posterior belly of the digastric, immediately below which is the internal jugular vein covered by its sheath. If it be decided to dissect the glands off the jugular from below upwards, the latter should be deliberately exposed below the diseased glands. For this purpose the lower edge of the wound must be well retracted so that the deep cervical fascia may be divided as low down as possible. If the glands be not adherent to the sheath of the internal jugular, their separation is a simple matter. The methods of dealing with the vein when the glands are adherent will be referred to later.

Having freed the glands from the common facial and internal jugular veins, the latter is retracted forwards and the small glands behind and external to it are removed; they are situated deeply on the origins of the splenius and levator anguli scapulæ muscles. To remove them the sterno-mastoid is retracted well backwards and the spinal accessory nerve is hooked aside. These glands, though small, are frequently tuberculous, and failure to remove them is often responsible for recurrence of the disease.

All bleeding having been carefully arrested, a small rubber drainage tube is drawn through a puncture opening made at the posterior margin of the sterno-mastoid opposite the lowest part of the wound. The tube should be directed upwards and inwards from the opening, and care should be taken to see that it does not press on the jugular; its inner extremity should reach to just behind the vein. The suturing and after-treatment of the wound have already been referred to.

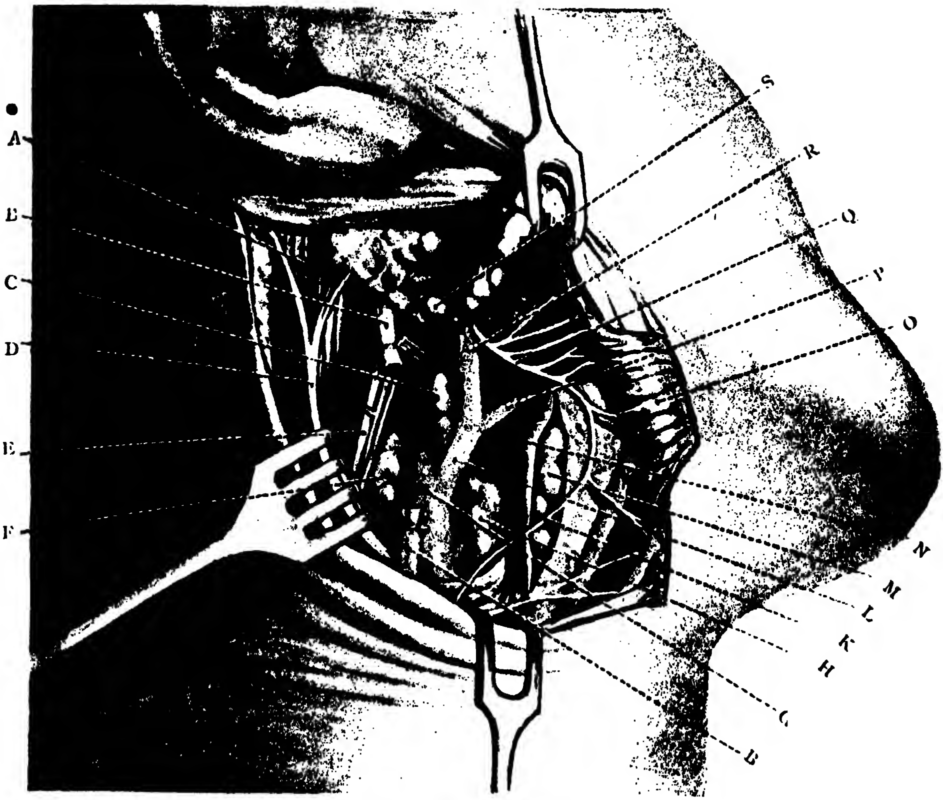


FIG. 3. THE UPPER DEEP CERVICAL GLANDS. Dissection to show the relations of the various anatomical structures met with in excising the upper deep cervical glands by the typical oblique incision extending from the posterior border of the mastoid process to the upper border of the thyreoid cartilage. A portion of the external jugular vein has been resected and the lower part of the parotid gland has been hooked upwards to show the inframandibular branch of the facial nerve; the anterior border of the sterno-mastoid has been retracted so as to expose the spinal accessory nerve and the accompanying superior sterno-mastoid vessels; the tonsillar lymphatic gland is well seen, occupying the angle between the common facial and internal jugular veins; the process of deep cervical fascia has been split to show the submaxillary salivary gland. A, Sterno-mastoid; B, B, External jugular vein; C, Tonsillar lymphatic gland; D, Great auricular nerve; E, Spinal accessory nerve and superior sterno-mastoid vessels; F, Upper posterior deep cervical glands; G, Internal jugular vein; H, Upper anterior deep cervical glands; K, Ramus communicans collo-mandibularis; L, Common facial vein; M, Submaxillary salivary gland; N, Stylo-maxillary ligament; O, Platysma; P, Facial vein; Q, Inframandibular branch of the facial nerve; R, Anterior temporo-maxillary vein; S, Parotid gland.

EXCISION OF BOTH POSTERIOR AND ANTERIOR GROUPS OF UPPER DEEP CERVICAL GLANDS

Here the mass extends backwards into the posterior triangle as well as forwards in front of the sterno-mastoid. By pushing the tumour backwards its outline will be seen to extend upwards as far as the tip of the mastoid process and backwards as far as the trapezius. The lower limit of the tumour generally tails off into a chain of glands which extends for a variable distance under and behind the posterior border of the sterno-mastoid. When the glands are large and softened, the muscle often produces an oblique constriction across the tumour.

FIG. 4. INCISION FOR REMOVAL OF THE ENTIRE CHAIN OF DEEP CERVICAL GLANDS.

The incision which has been recommended above for the removal of the anterior group of glands, even if carried to its full length, does not give sufficient access to the glands which occupy the posterior triangle. A long incision parallel to the sterno-mastoid and midway between its anterior and posterior borders would suffice, but the resulting scar would be conspicuous. A very satisfactory plan of dealing with such a mass of glands is to reflect a flap downwards and forwards off the tumour by means of an inverted J-shaped incision. The upper limb of the incision extends from about opposite the tip of the hyoid bone upwards and backwards to a finger's breadth below the angle of the jaw, thence in a curve directed across the upper part of the sterno-mastoid, behind which it descends vertically for a variable distance, depending on the extent to which the disease has extended downwards. The highest part of the curve reaches to just below the tip of the mastoid process. The descending or vertical limb is generally placed at, or a little in front of, the anterior border of the trapezius (see Fig. 4). The great advantage of this incision is that it gives free access to the glands in both triangles, and that it allows the anatomical structures in the field of operation to be clearly exposed to view. The upper limb of the incision is in the line of cleavage of the skin, and leaves therefore a fine cicatrix

in the direction of the natural creases of the neck. The vertical limb is far enough back to be to a large extent hidden from view. The only conspicuous part of the incision is the middle portion which is curved across the upper part of the sterno-mastoid. In cases in which the cosmetic result is a matter of great importance, the middle portion of the incision may be omitted, but in this case the anterior oblique portion of the incision should extend back to the tip of the mastoid process, while the posterior incision should extend up to a little behind the root of the same process. The access is, of course, not so free as it is by the flap incision, but by making the two wounds communicate under the sterno-mastoid, the disease can all be removed.

The steps in the dissection for the removal of the anterior group of glands are the same as above described. In removing the posterior group the posterior border of the sterno-mastoid is freed, after which its deep surface is dissected off the glands and the muscle is retracted well forwards. Before this can be done efficiently, it is generally necessary to divide the posterior fibres of the muscle just below their insertion. While the edge of the muscle is being freed, a careful search is made for the spinal accessory nerve, which becomes superficial about the middle of the posterior border of the muscle. The nerve is much more liable to be injured *after* rather than *before* it has pierced the muscle. When the nerve has been found, it should be freed in both directions so that it may be hooked either upwards or downwards as may be required. Behind the sterno-mastoid it is generally superficial to the glands, while before it pierces the muscle it frequently traverses them. Having freed and retracted the sterno-mastoid and the spinal accessory, the next step is to define the posterior limit of the mass, and then to dissect it from behind forwards off the splenius and levator anguli scapulæ muscles until the posterior aspect of the internal jugular is exposed. In doing this the knife may be carried boldly down to the muscles, as, apart from the spinal accessory nerve, there are no structures to be avoided. Not infrequently the glands will be found to have pushed their way into the septum between the splenius and the levator anguli scapulæ muscles. The superficial branches of the cervical plexus, namely, the small occipital, the great auricular, the transverse and descending superficial cervical nerves, may all be divided if necessary, as they are all purely sensory. The resulting anæsthesia is largely recovered from. The branches from the third and fourth cervical nerves to the trapezius should, if possible, be spared. By completely undermining the sterno-mastoid and retracting it forwards and backwards, the deeper parts of the two dissections are thrown into one.

Whether the flap method or two separate incisions be employed,

a single drain is usually sufficient; it should be introduced at the lower part of the vertical wound.

When the disease, in addition to involving both groups of upper deep cervical glands, implicates also the *lower posterior group* as far as the clavicle, the operation is practically the same as above described, with the addition that the supraclavicular glands have to be removed as well. Here, again, either the single J-shaped incision or two separate incisions may be employed; in either case the vertical incision is prolonged down to, or even a little below, the clavicle, which it reaches either at its middle or at the junction of its middle and upper thirds (see Fig. 4).

EXCISION OF THE ENTIRE CHAIN OF DEEP CERVICAL GLANDS

When the disease has advanced so as to involve *all the groups which go to form the deep cervical chain* the tumour-like mass extends from the mandible and mastoid process down to the clavicle. In aggravated cases the mass broadens out at the root of the neck so as to extend inwards behind the lower part of the sterno-mastoid as well as outwards and backwards under cover of the clavicular origin of the trapezius. In a case of this kind the best cosmetic result is got by dissecting out the whole mass through two long oblique incisions. The upper incision extends from an inch behind the tip of the mastoid process obliquely downwards and forwards to the thyreoid cartilage (see Fig. 2, B). The lower incision, which begins at, or a little external to, the middle line of the neck, one inch above the suprasternal notch, passes obliquely upwards, outwards, and backwards, to end a little behind the anterior border of the trapezius, about two inches above the clavicle (see Fig. 2, D). In a neck of average length there is usually no great difficulty in throwing the deeper parts of the two dissections into one. In the case of a long neck, however, and when there is no narrowing of the mass at the centre of the neck, the lower incision should be angular. The anterior limb is placed almost horizontally about a finger's breadth above the clavicle; the posterior limb passes upwards parallel to the anterior border of the trapezius as far as its middle, or higher if necessary. The angle between the two limbs is rounded (see Fig. 2, C). By this incision a triangular flap is reflected upwards and forwards off the lower half of the tumour. The dissection through the upper incision has already been described; it should be carried as far down the neck as possible so as to enable the upper mass of glands to be removed down to the level at which the internal jugular is crossed by the anterior belly of the omo-hyoid muscle.

The *lower dissection* must now be described in detail. If the oblique incision be used, the edges of the wound must be undermined so as to enable the flaps to be reflected as far as possible off the glands, the one

upwards, the other downwards. In doing this the descending superficial cervical nerves are, of course, divided. Owing to the pressure of the glands on the internal jugular, the lower part of the external jugular vein is often considerably dilated; it must therefore be carefully isolated and divided between two ligatures; these should be applied just before it pierces the cervical fascia at the posterior border of the sterno-mastoid,

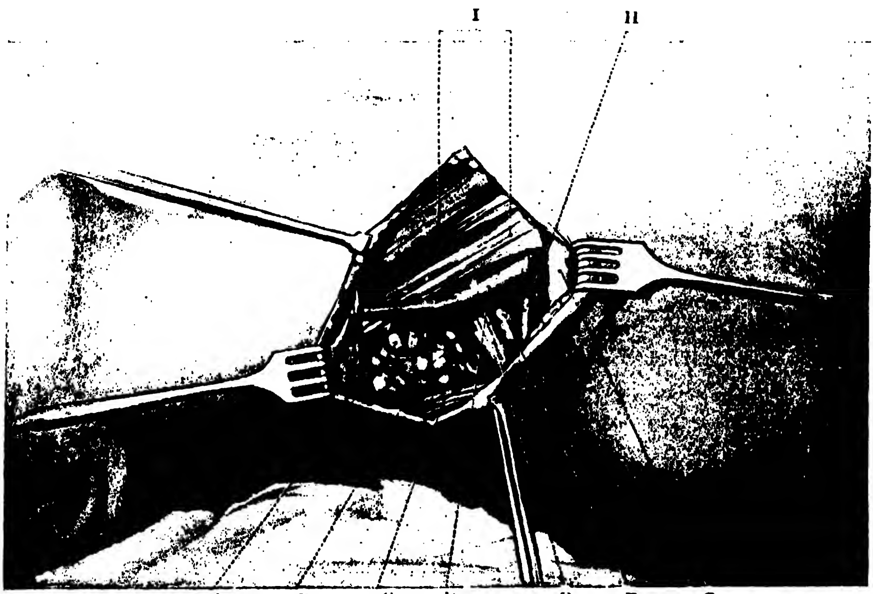


FIG. 5. THE LOWER DEEP CERVICAL GLANDS. Dissection to show the relations of the various anatomical structures met with in excising the lower posterior group of deep cervical glands by the lower oblique incision. The lowest and most superficial glands of this group have been removed to show the deeper structures. A, Lower posterior group of deep cervical glands; B, Levator anguli scapulæ; C, Trapezius; D, External jugular vein; E, Omo-hyoid; F, Supraclavicular lymphatic glands; G, Clavicle; H, Suprascapular vessels; I, Sterno-mastoid.

a little above the clavicle. After reflecting the superficial structures off the lower part of the sterno-mastoid muscle, its posterior border is freed as high up as possible; and in order to reach the anterior limit of the mass it will generally be necessary to divide more or less of the clavicular fibres of the muscle a little above the clavicle. The lower edge of the wound is retracted downwards and backwards so as to expose the clavicle and the lower half of the anterior border of the trapezius. In freeing this muscle from the lower and posterior limit of the mass, care should

be taken not to injure the spinal accessory nerve; it should be freed in the whole of its course across the posterior triangle, so that it may be retracted out of the way. If the branches of the third and fourth cervical nerves to the trapezius can also be dissected free, so much the better; not infrequently, however, it is impossible to preserve them.

When the lower and posterior angle of the chain extends downwards and backwards for a considerable distance under cover of the clavicular origin of the trapezius, it may be necessary to divide some of its fibres transversely. In dissecting the mass up from the deeper structures it is best to begin from below by dividing the general envelope of deep cervical fascia immediately above the clavicle. When this has been done, the finger or a blunt dissector is passed beneath the lower edge of the mass, which is then dissected upwards off the posterior belly of the omo-hyoid and the middle layer of the cervical fascia. By dividing the fascia the omo-hyoid may be completely freed and retracted out of the way, but when the glands are very adherent it must be removed. The next step consists in retracting the clavicular portion of the trapezius and dissecting out the glandular prolongation which extends downwards and backwards behind the outer third of the clavicle; this can often be done to a large extent with the finger aided by blunt-pointed scissors. The glands are here embedded in a quantity of fatty cellular tissue which contains a plexus of veins large enough to necessitate the application of artery forceps. Posteriorly the glands lie upon the upper digitations of the serratus magnus and the posterior thoracic nerve; the latter lies under the fascia, and is, therefore, protected from injury.

Having got well behind the glands, both inferiorly and posteriorly, the next step is to dissect the chain upwards off the brachial plexus and the scalenus medius. In doing this the transversalis colli artery and vein are divided, but the brachial trunks, including the supra-scapular nerve, which springs from the junction of the fifth and sixth cervical nerves, are not likely to be injured, as they are covered by the continuation outwards of the prevertebral layer of deep cervical fascia. The nerve to the rhomboids, and the two roots of the posterior thoracic nerve, lie still deeper, behind the scalenus medius. When the upper wound is nearly reached the glands situated beneath the bridge of soft parts are brought within reach by pushing them downwards with two fingers introduced into the upper wound. The ascending cervical branch of the inferior thyreoid artery is generally divided at this stage of the operation.

The final stage of the dissection consists in the removal of the lower and anterior group of the chain, the anatomical relations of which are

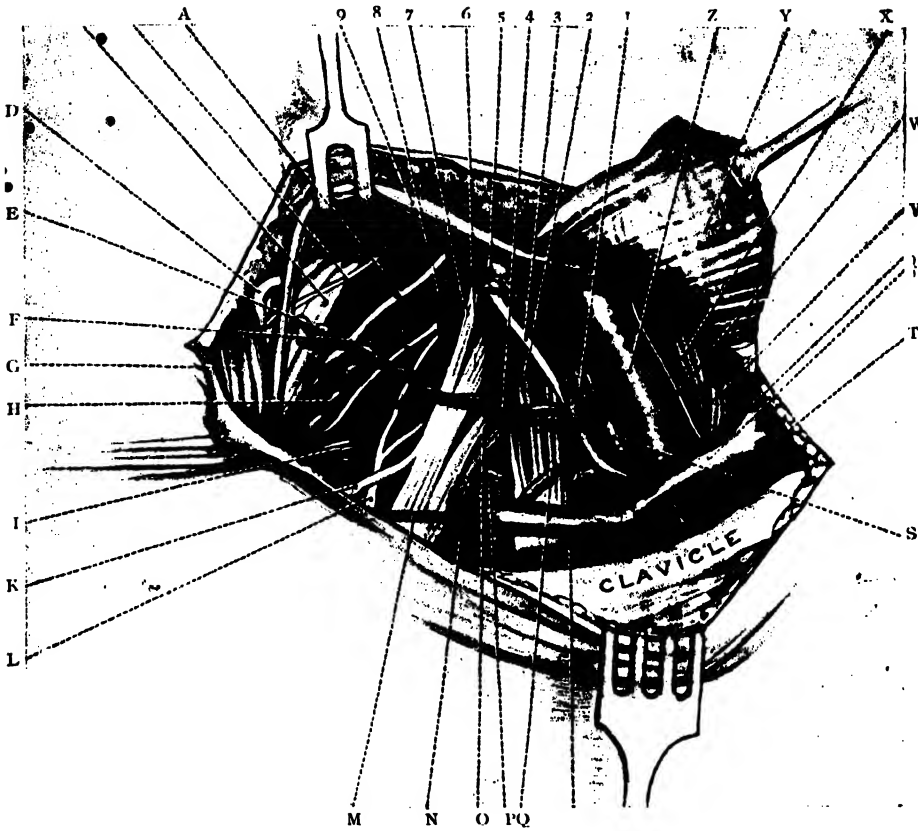


FIG. 6. FURTHER STAGE OF THE DISSECTION SHOWN IN THE PREVIOUS FIGURE. To illustrate the relations of the various structures met with in excising the anterior as well as the posterior group of the lower deep cervical glands by an incision extending obliquely backwards and slightly upwards from immediately above the inner end of the clavicle. The clavicular origin of the sterno-mastoid has been divided and thrown upwards, while the omo-hyoid has been freed and retracted upwards; a portion of the external jugular vein has been resected. A, Nerve to the levator anguli scapulæ; B, Branch from the cervical plexus to the trapezius; C, Levator anguli scapulæ; D, Spinal accessory nerve; E, Superficial cervical artery; F, Nerve to the rhomboids; G, Trapezius; H, Posterior scapular artery; I, Serratus magnus; K, Suprascapular nerve; L, Posterior thoracic nerve; M, Suprascapular vein; N, Subclavian artery; O, Seventh cervical nerve; P, External jugular vein ligatured; Q, Suprascapular artery; R, Subclavian vein; S, Vertebral vein; T, Anterior communicating vein; U, Anterior jugular vein; V, Sterno-hyoid; W, Descendens hypoglossi; X, Sterno-thyreoid; Y, Sterno-mastoid; Z, Internal jugular vein; 1, Inferior thyreoid artery; 2, Scalenus anticus; 3, Phrenic nerve; 4, Transversalis colli artery; 5, External jugular vein; 6, Sixth cervical nerve; 7, Fifth cervical nerve; 8, Scalenus medius; 9, Omo-hyoid.

important. In front of these glands are the clavicular portion of the sterno-mastoid, the middle layer of deep cervical fascia, and the outer part of the sterno-hyoid and sterno-thyreoid muscles; posteriorly they rest upon the internal jugular vein, the scalenus anticus, and the phrenic nerve. To gain access to them the posterior border of the sterno-mastoid muscle must be retracted well forwards, and, if necessary, more or less of its clavicular fibres should be divided close to their origin from the clavicle. The anterior belly of the omo-hyoid is freed from the jugular sheath and retracted upwards. After dividing the middle layer of the cervical fascia the glands themselves are exposed. There is usually no difficulty in getting below them, and in dissecting them upwards off the lower part of the internal jugular, the scalenus anticus muscle, and the phrenic nerve. There is no fear of injuring the nerve, as it lies behind the fascia covering the muscle. The fascia is a prolongation outwards of the prevertebral fascia. Not infrequently this chain of glands dips behind the lower part of the internal jugular, and when this is the case, great care should be taken to keep the edge of the knife as close to the glands as possible. Neglect of this precaution may result in a wound of the internal jugular vein, the vagus, or the thoracic duct.

On more than one occasion the writer has found a subsidiary chain of diseased glands lying internal to the scalenus anticus, between the inner edge of the internal jugular vein and the vertebral vein. These glands are important because they lie in close relation to the thoracic duct, which arches outwards behind the lower part of the internal jugular vein between it and the vertebral vein. To remove them, the lower part of the jugular is retracted inwards, while the glands themselves are carefully peeled off the vertebral vein. If possible, blunt dissection should be substituted for the knife, but if this does not suffice, great care should again be taken to keep the edge of the knife directed against the glands. In a case operated on recently by the writer, in which these glands were diseased, the thoracic duct was clearly exposed and avoided. It lies in a quantity of loose cellular tissue, and, being itself very elastic, it is easily pushed aside. Some little trouble may be occasioned by the division of a vein close to its junction with the vertebral vein.

As regards drainage, when two oblique incisions are employed, the upper wound is drained by a tube pulled beneath the sterno-mastoid through a puncture opening made midway between the posterior portions of the upper and lower incisions. The lower wound is drained by a tube placed horizontally across the root of the neck and brought out at a puncture opening a little above the junction of the upper and middle third of the clavicle. If the disease extends far back under cover of the trapezius the opening for the tube may be made still further back

through, instead of immediately in front of, the fibres of the trapezius. When the lower incision is angular, the upper wound may be drained by bringing the tube out at the upper extremity of the vertical limb of the lower wound, while the latter is drained by a tube brought out either at the angle of the incision or through a separate opening placed further back. In many cases when the upper wound is large, to make sure of efficient drainage, the writer frequently inserts a very small, almost capillary, drainage tube into the main wound between two of the stitches; the lumen of the tube, although small, is sufficient to allow of the escape of the early serous exudation, while its presence leaves no trace in the cicatrix.

EXCISION OF THE SUBMENTAL GLANDS

When the submental glands are alone diseased they may be removed either through a vertical median incision extending from the symphysis menti to the hyoid bone, or through an incision parallel to and a little below the lower margin of the mandible. Unless the glands form a distinct vertical chain, the latter incision is to be preferred; it leaves a better cicatrix, and if the glands in the anterior part of the digastric triangle are found to be diseased, they can be got at by prolonging the incision outwards. Tributaries of the anterior jugular veins are divided in the superficial fascia. The glands are exposed as soon as the general envelope of deep cervical fascia is split; indeed, they are generally adherent to it. There are no important structures to be avoided, so that the glands may be dissected boldly off the anterior bellies of the digastrics and the intervening portions of the mylo-hyoid muscles. Occasionally the glands are so firmly adherent to one of the digastrics that a portion of the muscle may have to be removed. One or two muscular branches of the submental arteries will probably require to be ligatured.

EXCISION OF THE SUBMAXILLARY GLANDS

To remove the submaxillary group an incision is made from a point about a finger's breadth below the angle of the jaw forwards to a point midway between the symphysis menti and the hyoid bone. Between these two points the incision should curve downwards to the level of the tip of the great cornu of the hyoid bone, so as to avoid dividing the inframaxillary branch of the facial nerve. The posterior extremity of the incision is in front of the external jugular vein, but the anterior jugular is divided at the anterior part of the wound. The glands are exposed as soon as the general envelope of deep cervical fascia is divided. They lie partly below and partly under cover of the mandible. The best plan is to dissect them in the first instance from below upwards off the

digastric and stylo-hyoid muscles, and then off the hyoglossus and the posterior part of the mylo-hyoid. The glands are so intimately related to the superficial portion of the submaxillary salivary gland that its removal is generally necessary. The hypoglossal nerve and ranine vein are bound down to the hyoglossus by the fascia which covers it, so that unless the glands are exceptionally adherent there is little danger of injuring them; the vein, however, may be wounded unless the knife be kept close to the glands. In dissecting forwards the posterior glands of the chain from the stylo-maxillary ligament, which separates them from the parotid gland, the anterior trunk of the temporo-maxillary vein is isolated and divided between forceps. When the glands are being separated from the mandible, the facial vessels are generally divided; the vein lies superficial to the submaxillary gland, while the artery is embedded in a groove on its deep surface. In front of the submaxillary salivary gland the lymph glands lie on the mylo-hyoid muscle, and here one or two of them are often hidden away in a pocket under cover of the mandible, to which they may be adherent. In removing them the submental branch of the facial artery is generally divided, but by keeping close to the glands the mylo-hyoid branch of the inferior dental nerve may often be avoided. Anteriorly, the chain is in contact with, and often adherent to, the anterior belly of the digastric muscle. The sublingual salivary gland, the lingual nerve, and the terminal portion of the hypoglossal are all protected from injury by the mylohyoid muscle. When the glands which extend up under cover of the angle of the jaw have become firmly adherent to the stylo-glossus muscle and the stylo-maxillary ligament, there may be some difficulty in securing the facial artery and the temporo-maxillary vein. The difficulty may be overcome by prolonging the incision further back so as to free more of the posterior belly of the digastric, which is then well retracted downwards and backwards. The wound may be drained by placing a small tube in the main incision; sometimes, however, it is more convenient to bring the tube out through a special puncture below the incision.

When the infection proceeds from the anterior part of the mouth it is quite common to find the submaxillary glands involved on both sides, in which case both submaxillary triangles should of course be cleared at the same operation.

When the submaxillary glands are involved along with the deep cervical glands on the same side, the J-shaped incision already described for the removal of the deep cervical chain (see Fig. 4) is employed, being modified merely to the extent of carrying the submaxillary limb to a point midway between the symphysis menti and the hyoid bone. By this incision the skin is reflected downwards and forwards off the side of the neck in the form

of one large triangular flap. Or a T-shaped incision may be employed, one limb extending along the posterior border of the sterno-mastoid, the other from the junction of the upper and middle third of this incision obliquely upwards and inwards to a little above the middle of the hyoid bone. By this combination of incisions two flaps are dissected off the neck, the one upwards and forwards towards the mandible, the other downwards and forwards towards the middle line. When only the upper part of the deep cervical chain is involved along with the submaxillary group, the disease can be removed through a single oblique incision, extending from a little behind the base of the mastoid process to the hyoid bone. By retracting the lower edge of the wound well downwards, the glands may be removed down to where the internal jugular is crossed by the anterior belly of the omo-hyoid muscle.

FIG. 7. INCISIONS FOR REMOVAL OF THE SUBMAXILLARY TOGETHER WITH THE DEEP CERVICAL GLANDS.

OPERATIVE PROCEDURES WHEN THE DISEASE IS COMPLICATED WITH ABSCESSES AND SINUSES

When one or more of the glands of a diseased group have softened and formed a caseous abscess a radical operation should still be performed, and an endeavour should be made to remove all the disease without rupturing or opening into the abscess. Should the abscess be unavoidably opened, all the caseous pus should be squeezed out and wiped away at once, so as to reduce the soiling of the wound to a minimum. In some cases it is an advantage, before proceeding with the dissection, to curette the softened gland, and swab it out with pure carbolic acid. In consequence of the periadenitis which generally results from the suppuration, the gland capsules often become very adherent to the surrounding structures. Fortunately, however, the worst adhesions are generally between the glands and the structures superficial to them, namely, the cervical fascia and the sterno-mastoid. After these have been dealt with there is often comparatively little difficulty

in separating the glands from the deeper structures, namely, from the internal jugular vein, from the digastric, and from the muscles forming the floor of the posterior triangle. In cases in which a radical excision seems at first to be almost impossible, with care and perseverance all the disease may often be removed and a clean dissection left. Sometimes, however, the capsule of a deep suppurating gland has become so firmly adherent to the internal jugular that it is impossible to dissect it off. The operator must then either resect a portion of the vein or leave behind the adherent portion of the capsule. The latter plan is generally permissible, provided the portion of the capsule left is well curetted and treated with pure carbolic acid.

When the caseous process has spread through the glands and infiltrated the upper half or so of the sterno-mastoid muscle, the diseased portion must be removed along with the glands. At the close of the operation the divided end of the muscle should be stitched with interrupted catgut sutures either to the levator anguli scapulæ or to the scalenus medius, depending on the amount of muscle removed. In cutting across the muscle it is well to do so obliquely so as to leave the anterior border longer than the posterior; the advantage of this is that a greater extent of the internal jugular vein will be overlapped by the muscle.

Unfortunately, it often happens that the disease is allowed to progress until the caseous abscess into which the gland has become converted has become adherent to, and ruptured through, the general envelope of deep cervical fascia. The perforation of the cervical fascia is soon followed by the development of a subcutaneous abscess. In such a case it is important to operate before the skin itself becomes involved. It is the reverse of good surgery to limit the operation to curetting the abscess in the hope that the glandular mischief which has given rise to it will subside. The result of such a procedure is generally to leave the patient with a persistent sinus. It is this kind of surgery which brings the operative treatment of cervical glands into disrepute. The proper way to deal with such a case is to lay open the abscess freely by whatever incision is best adapted for the removal of the subjacent glands. If the skin over the abscess be already involved, the incision should not be carried through the diseased area of skin, as that only serves to encourage the formation of a tuberculous cicatrix. The better plan is to curve the incision downwards so as to skirt the margin of the involved skin. The flap is then dissected up, and the anterior wall of the abscess is clipped or scraped away from the flap, and some iodoform-bismuth paste is rubbed into the raw surface. The floor of the abscess, which is formed by the deep fascia, is treated in the same way. The opening

leading from it into a subjacent gland is investigated, and, if necessary, the sinus and the cavity into which it leads are curetted and swabbed out with pure carbolic acid. The deep fascia is then cautiously divided at whatever part leads most safely to the exposure of the glands, which are dissected out in the usual way. As already stated, the adhesions are less troublesome in the depth of the wound than they are towards the surface. After freeing and retracting the sterno-mastoid muscle, the two most useful landmarks to make for are the posterior belly of the digastric and the internal jugular vein. It is often a good plan to make sure of the whereabouts of the latter by deliberately exposing it in the first instance below the level of the diseased glands. The common facial vein is also a useful guide, but in the cases here referred to the glands are generally so adherent that its division is often unavoidable.

If the skin over the subcutaneous abscess be so involved by the subjacent tubercle that it is past recovery the incision must be so planned as to excise it. It may be included in either an elliptical or a triangular incision, both of which are made to form part of the main incision for the removal of the diseased glands. If the area of skin removed be not too large, the wound can generally be closed by freely undermining the flaps; if, on the other hand, this cannot be done, the part of the wound which is left open is either stuffed with iodoform gauze or utilized for drainage.

When persistent sinuses are present they are practically always due to the presence of a caseous gland, or glands, under the cervical fascia. Not infrequently the sinus owes its persistence to the remains of a single tuberculous gland capsule. Here, just as in the case of the subcutaneous abscess, it is seldom advisable to limit the operative treatment to scraping the sinus. Such treatment may cause the sinus to heal up for a time, but the cure is seldom permanent. The proper course to adopt is to excise the diseased gland, or glands, along with the sinus. Before commencing the dissection the latter should be scraped and thoroughly disinfected with pure carbolic acid. If more than one sinus exists some ingenuity may be called for in planning the most suitable incisions.

OPERATION FOR RETROPHARYNGEAL ABSCESS

The retropharyngeal abscess of glandular origin lies in front of the prevertebral fascia, whereas that which occurs secondary to spinal caries lies behind it. The glandular abscess originates in one of the lymphatic nodes which lie in the cellular space bounded anteriorly by the fibrous envelope of the pharynx, posteriorly by the prevertebral fascia, and laterally by the lateral pharyngeal fascia, which forms the inner wall of the carotid sheath. There are generally one or two of these glands situated on either side of the middle line, opposite

the upper two cervical vertebrae. They receive efferent lymphatic vessels from the naso-pharynx. When suppuration occurs in one of these glands the abscess pushes the posterior wall of the pharynx forwards so as to form a distinct fluctuating swelling on one or other side of the middle line. The spinal abscess, on the other hand, generally crosses the middle line. Unless the posterior wall of the pharynx has become so thin that perforation is imminent, the abscess should be opened from the neck. This is a simple enough matter when the upper deep cervical glands are also tuberculous. After these glands have been removed the internal jugular vein is freely exposed, so that to reach the wall of the abscess all that is necessary is to retract the vein forwards and inwards along with the carotid vessels. After the abscess has been opened, its cavity is curetted, care being taken not to perforate the wall of the pharynx. Some sublimated iodoform-bismuth paste is applied to the cavity, which is stuffed with a strip of iodoform gauze, one end of which is brought out at the wound in the neck. If the gauze strip does not give sufficient drainage, a tube may also be introduced.

When, however, the retropharyngeal abscess is the only manifestation of the tuberculous disease in the neck, a careful and definite open dissection must be made to reach it. In the spinal cases the abscess is best reached through an incision made along the posterior border of the sterno-mastoid (see Vol. II, p. 42). In the retropharyngeal glandular abscess, however, the abscess is more easily reached through an incision almost parallel to its anterior border. After splitting the cervical fascia the sterno-mastoid is retracted well backwards, the posterior layer of its sheath is divided, and the spinal accessory nerve is freed and retracted upwards and backwards. The chain of small lymphatic glands which lies posterior to the internal jugular vein is then removed, after which the vein and its sheath are retracted forwards. The posterior belly of the digastric muscle is freed and retracted upwards and forwards. If there be any doubt as to whether the wall of the abscess has been reached, a gag should be placed in the mouth and an assistant should introduce his forefinger and make pressure on the abscess so as to cause it to bulge into the depth of the wound. The abscess is carefully opened either by a small incision or by perforating its wall with sinus forceps (or with a pair of Kocher's artery forceps), the opening being enlarged by separating the blades (Hilton's method). The cavity of the abscess is then treated as above described. The wound is sutured, an opening being left for the gauze strip with which the abscess is lightly stuffed. The dressing is not disturbed until the third or fourth day, when a fresh strip of iodoform gauze is introduced. At the next dressing the stitches and gauze are removed and the opening is allowed to close.

CHAPTER II

COMPLICATIONS OCCURRING DURING OPERATIONS UPON TUBERCULOUS CERVICAL GLANDS: RESULTS

Injuries to veins. When the glands have become adherent considerable difficulty is often experienced in dissecting them off the internal jugular vein. As long as the adhesions are outside the sheath, the latter may be stripped off the vein along with the glands, and this can often be done by blunt dissection. When it is necessary to use the knife, the glands should be seized with toothed forceps and pulled away from the vein, while the edge of the knife, which should be as sharp as possible, cuts cautiously towards the glands. With each touch of the knife, the vein will be seen to fall away from the gland. When, on the other hand, the sheath is firmly adherent to the jugular as well as to the glands, a portion of the vein must be resected. The vein is in the first place isolated and divided between two ligatures below the adherent glands, after which there is generally no difficulty in stripping it and the glands from below upwards off the carotids, the vagus, the sympathetic, and the prevertebral fascia. Some difficulty, however, may be met with in exposing and ligaturing the vein above the adherent glands. To do this the digastric muscle must be freed and retracted well upwards; and if the glands which extend upwards behind it are firmly adherent to it, a portion of the muscle must be removed. When, as is generally the case, the upper ligature has to be applied above the entrance of the common facial vein, the latter must also be ligatured. The advantage of ligaturing the jugular in the first instance *below* the glands is that the vein is more easily followed up when it is distended with blood.

It occasionally happens that the vein is wounded in attempting to dissect very adherent glands off it. The injury may take the form either of a puncture or a small tear. Speaking generally, the best plan is temporarily to close the opening with artery forceps and to defer dealing with it until after the glands have been removed. In cases where there is a possibility of the vein being opened, the digastric muscle should be freed and retracted well upwards so as to provide room for controlling the vein above where it is likely to be wounded. When the hæmorrhage

occurs unexpectedly, and the bleeding point is invisible, the wound should at once be firmly plugged. If, on removing the gauze, the opening in the vein be still invisible, or inaccessible, the part of the wound from which the hæmorrhage occurs should again be plugged so as to check the active bleeding while the operator proceeds to remove the glands which obscure the vein. If room can be got to ligature or clamp it above the bleeding point, the main difficulty will have been overcome. The most common place to wound the jugular is where the common facial opens into it. In such a case the latter vein must be ligatured as well, and sometimes also the thyreo-lingual trunk.

It must not be forgotten that the division of a small vein close up to its entrance into the jugular amounts, practically, to a puncture of the latter vein itself. The operator must beware of trusting to a lateral ligature in arresting hæmorrhage from a puncture in either the jugular or the common facial; such a ligature may suffice to arrest the bleeding while the patient is fully anæsthetized, but there is a considerable risk of the ligature becoming detached by the sudden venous engorgement which occurs during vomiting. Twice this accident has happened to the writer; once just after the wound was sutured, and on the second occasion immediately after the patient had been put back to bed. In both cases, fortunately, the complication was successfully dealt with; in the one case by ligaturing the entire vein above and below the puncture, and in the other by suturing it. Unless the opening in the vein is a large one, it is better to deal with it by suturing rather than by double ligaturing the vein. Before applying the sutures the vein is gently clamped above and below the opening so as to allow the forceps which close it to be removed without the occurrence of hæmorrhage. The suture, which should be of fine catgut and continuous, is introduced by means of a fine sewing-needle. After closing the opening in the wall of the vein itself, the edges of the sheath—or any fascial structures in the neighbourhood—should be brought together over it with a second row of sutures.

When a small area of the sheath of the vein has been removed along with an adherent gland, it sometimes happens that the exposed portion of the wall of the vein becomes herniated through the deficiency. When this occurs it is advisable to suture the edges of the sheath over the protrusion.

In dissecting out adherent glands from the parotid, the veins in its substance, *viz.* the divisions of the temporo-maxillary and the commencement of the external jugular, often bleed rather freely. They are prevented from collapsing by the adhesion of their walls to the somewhat dense stroma of the parotid, and for the same reason it is sometimes difficult to get a sufficient pedicle to prevent the ligature from slipping; the

difficulty may be overcome by carrying the ligature underneath the vein with the assistance of a curved needle.

If the lower part of the external jugular vein be wounded, it should be occluded at once, either with the point of the finger or by the pressure of a gauze swab, otherwise air is liable to be sucked in during inspiration. The pressure must not be removed from the vein until the assistant is ready with his artery forceps to secure the opening. Although the writer has more than once heard air being aspirated into the vein with the characteristic hissing or whistling sound, neither he nor the anæsthetist has observed any untoward effects, either immediate or remote, resulting from it.

Injury to the thoracic duct. Neither at nor subsequent to the operation has the writer become aware that he has ever injured the thoracic duct in excising tuberculous cervical glands. This injury has, however, occurred with sufficient frequency to call for a reference to it. In the *Edinburgh Medical Journal* for October, 1907, Mr. W. J. Stuart, after recording a case of his own, gives a valuable summary of forty-two recorded cases in which the cervical portion of the duct was injured during surgical operations, sixteen of which were for the removal of tuberculous glands ; nearly all the rest were for the removal of malignant glands. Death occurred in only five (12·5 %) of the cases, so that the injury is by no means so fatal as is often stated. The reason for this is explained by the method in which the duct is connected to the venous system. According to Lower and Tiechmann, the duct frequently opens into the junction of the internal jugular and subclavian veins in a delta-like manner by several channels, or it may subdivide into two or three large terminal branches which enter different veins. When, therefore, only one of the terminal divisions is divided, the others suffice to convey enough chyle into the circulation. 'Even should complete section occur of a duct which has only a single ending, there is usually a sufficient number of thoracic or abdominal communications with the venous system to prevent that death from inanition which the older surgical writers regarded as the inevitable consequence of division of the great chyle-conducting trunk. These communications are probably in many cases enlarged, owing to pressure upon the duct near its termination by the tumour or enlarged glands for which the operation is performed.'

The accident declares itself at the time of the operation by 'the sudden flooding of the wound with a fluid which may be almost clear, as the patient has usually had no food for some hours, or clear but mingled with whitish threads, or distinctly milky like skimmed milk or milk mixed with water. Frequently a search reveals the cut end of the

duct or a wound in the wall, from which the fluid escapes; and it is interesting to note that this escape is frequently rhythmical, a little jet being expelled at each expiration, showing how important a part the respiratory movements play in the propulsion of chyle through a vessel whose walls are very sparsely supplied with muscular tissue' (Stuart). Should the injury escape notice at the operation it is manifested subsequently either by the subcutaneous collection of a whitish fluid, or by the establishment of a fistula, from which there is often a lymphorrhœa or chylorrhœa sufficiently profuse to soak through the dressing and to produce rapid emaciation and feebleness along with great thirst and hunger.

With regard to treatment, the writer cannot do better than reproduce the following paragraph from Stuart's paper: 'The best treatment, if the wound of the thoracic duct is recognized during the operation, is ligature of the peripheral end; ligature of the central end in addition is in most cases unnecessary, but can do no harm. Suture of a wound in the duct is worth attempting only in very favourable cases. Packing is only justifiable if the surgeon is unable to apply a ligature.

'The best treatment, if the wound of the thoracic duct is not recognized till after the operation, is probably firm packing of the wound, which almost invariably results in cure with or without a comparatively short-lived fistula. Firm supraclavicular external pressure may be successful if the wound is firmly closed, and may also be successful even if the wound is not closed; there have been too few cases of this treatment to allow of a definite expression of opinion upon it. Probably where the accumulation in a closed wound is recognized as being chylous, supraclavicular pressure—the accumulation being left *in situ*—will be a safe and satisfactory method. The wound may be reopened, and a ligature or forceps applied to the duct, usually with complete success; but this is a difficult procedure, and hardly justifiable unless packing has been tried and has failed.'

Nerve lesions. The two motor nerves most commonly injured are the inframandibular branch of the facial and the spinal accessory. Unfortunately it is sometimes impossible to avoid dividing these nerves.

The *inframandibular branch of the facial* pierces the general envelope of deep cervical fascia a little behind the angle of the jaw and then descends under the platysma to join the ascending branch of the transverse superficial cervical nerve. Before supplying branches to the platysma the nerve gives off a branch which passes forwards and upwards to join the supramandibular branch of the facial almost immediately in front of where the facial vessels cross the lower border of the mandible. Jaffé has shown that this anastomotic branch, which he terms the ramus anastomoticus collo-mandibularis, contains the nerve fibres which supply

the depressor labii inferioris. The portion of the supramandibular branch of the facial behind the anastomosis contains no fibres which go to the above muscle. Hence, paralysis of the lower lip is caused either by division of the inframandibular branch of the facial before it gives off the anastomotic branch, by division of the latter, or by division of the supramandibular branch after it has been joined by the anastomotic branch. Jaffé has further shown that the ramus anastomoticus collo-mandibularis in more than half the cases leaves the inframandibular branch of the facial at, or even a little below, the level of the hyoid bone. In the remaining instances it comes off further backwards nearer the angle of the jaw. The variation, therefore, in the extent to which the fibres which supply the depressor labii inferioris reach below the posterior third of the horizontal ramus of the jaw, accounts for the fact that an incision placed at a given level below the jaw will cause paralysis of the lower lip in one case and not in another. Kocher recommends that the 'normal incision' for the upper part of the anterior triangle of the neck should extend from the mastoid process to the middle of the hyoid bone, and that it should lie a finger's breadth below and behind the angle of the jaw. As Jaffé rightly points out, when the anastomotic branch to the depressor labii inferioris arises low down, it will be divided by this incision. It is better, therefore, to make the normal incision at a lower level.

In clearing out the submaxillary triangle, the fibres which supply the depressor labii inferioris will escape if the posterior extremity of the incision be kept half an inch in front of the point where the facial vessels cross the lower border of the mandible (Jaffé). To clear out the posterior part of the digastric triangle Jaffé recommends that a second incision be made in a direction from the tip of the mastoid process towards the thyreoid cartilage. In some cases, however, especially when the glands in the parotid compartment of the digastric triangle are very adherent, it is impossible to avoid injuring the inframandibular branch of the facial, with the result that paralysis of the depressor labii inferioris occurs. The paralysis manifests itself by more or less complete immobility of the lower lip on the affected side; it is most noticeable when the patient laughs or attempts to show the teeth. While the paralysis is in some cases permanent, in the majority of instances it is only temporary, and in these cases it is evident that some of the nerve fibres which go to the muscle have escaped injury. The division of the platysma, and of some of the nerve filaments which supply it, no doubt accounts for many of the cases of slight transient paralysis of the lower lip.

The most important lesion following excision of tuberculous cervical glands is undoubtedly that which results from *division of the spinal*

accessory nerve. This nerve is subject to considerable variation in size, as well as in the level and depth at which it pierces the sterno-mastoid muscle. As a rule, it passes downwards and backwards in front of the internal jugular vein, but occasionally it passes behind it. The variation in size is due to the fact that the third and fourth cervical nerves often take a larger share than the spinal accessory in supplying the trapezius—indeed, in a few instances the spinal accessory has been found to end in the sterno-mastoid. The nerve is much more liable to be injured in the posterior than in the anterior triangle. In some cases it is impossible to get away all the glands without removing a portion of the nerve. In other cases the nerve is merely divided, in which case the two ends should be united at the close of the operation with a fine silk suture; and to prevent the nerve from becoming embedded in cicatricial tissue, it is well to surround it with a piece of Cargile membrane.

When the trapezius is completely paralysed the shoulder droops, the neck on the same side appears longer, and the inferior angle of the scapula is unduly prominent as well as rotated inwards towards the spine. When the patient shrugs the shoulder the atrophy of the trapezius is shown by the greater prominence of the levator anguli scapulæ on the affected side. The upper extremity hangs somewhat heavily from the shoulder, and fatigue is produced by occupations which entail a sustained support of the weight of the limb. Owing to the fixation of the scapula, movements involving elevation of the limb up to and above the level of the shoulder are performed with greater effort than normal. In many cases, however, it is often remarkable what little functional disability is complained of in cases in which the spinal accessory nerve is known to have been sacrificed. The loss of this nerve is a small price for the patient to pay for getting rid of an extensive mass of disease. When the nerve is divided before it pierces the sterno-mastoid the latter muscle is to a large extent paralysed, as it receives more of its nerve-supply from the spinal accessory than from the second and third cervical nerves. The trapezius, on the other hand, is only partly paralysed if the branches to it from the third and fourth cervical nerves escape injury. When, however, these nerves as well as the spinal accessory have been sacrificed, the trapezius is completely paralysed. The other motor nerves have already been sufficiently referred to.

The only important complications arising from division of the cutaneous branches of the cervical plexus are the neuralgias and radiating pains which sometimes result when the stumps of these nerves are involved in a cicatrix in the region of the posterior border of the sterno-mastoid muscle. In some cases the neuralgia is so severe, and so aggravated by the movements at the shoulder, that the cicatricial tissue must be excised.

RESULTS OF OPERATIONS UPON THE CERVICAL GLANDS

The results of excision of tuberculous cervical glands are most satisfactory. Unless the disease be unusually extensive the mortality is practically nil, and even in extensive cases it is probably not greater than 1 %. The writer has had two cases—both very extensive—in which death occurred suddenly within forty-eight hours of the operation. No post-mortem was allowed, and it was not possible to say exactly what the fatal result was due to. In children delayed chloroform poisoning has certainly been responsible for some of the deaths. The ultimate results—provided the operation be sufficiently radical—are equally satisfactory. Among ninety-six patients followed for periods of from three to thirteen and a half years Dowd (*Surgery, Gynecology, and Obstetrics*, March, 1909) found 93·7 % of apparent cures; one patient died of phthisis, five had recurrence in the glands, and in all these an ultimate cure was anticipated. According to Dowd 'patients who have passed five years in good health since operation need have little fear of recurrence'. Most surgeons will agree that his statistics 'surely substantiate the statement that the neck is a particularly favourable site for the surgical treatment of tuberculosis and that the operation is one of the most satisfactory of surgical procedures'.

CHAPTER III

OPERATIONS FOR THE REMOVAL OF TUBERCULOUS GLANDS FROM THE AXILLA AND THE GROIN

EXCISION OF THE AXILLARY GLANDS

THE glandular disease in the axilla may occur either alone, or it may be associated with tuberculous cervical adenitis. It is not infrequently secondary to tuberculous disease in the mamma, in which case the latter organ is removed along with the glands. Occasionally it is secondary to tuberculous disease of a rib.

The diseased glands generally form a nodular tumour-like mass which projects towards the base of the axilla and extends upwards under cover of the pectoral muscles towards the clavicle. Not infrequently isolated glands may be felt in addition to the main mass; these often lie in front of the posterior fold of the axilla, in relation to the subscapular vessels. When the subclavicular glands are involved they can often be detected by deep palpation through the infraclavicular triangular depression corresponding to the interval between the adjacent borders of the pectoralis major and deltoid muscles.

Operation. To remove the axillary glands an incision is made along the anterior fold of the axilla. By prolonging its extremities on to the chest-wall and upper arm respectively, the necessary access may be got for removing the disease should it prove to be more extensive than was anticipated. After splitting the axillary fascia the glands are freed from the lower borders of the pectoralis major and minor muscles, and forceps are applied to the long thoracic artery. The posterior flap is dissected back off the glands until the edge of the latissimus dorsi is well exposed. The assistant now retracts the pectoral muscles well upwards and forwards, while the surgeon proceeds to separate the glands from their attachments. In many cases this can be done to a large extent by the finger, by gauze dissection, aided if necessary by the knife, by blunt-pointed scissors, or by a blunt dissector. The operator will generally find it most convenient in the first instance to separate the glands from the serratus magnus by working from before backwards and from below upwards. The intercosto-humeral nerve is divided, but care should be taken not to injure the posterior thoracic nerve, which runs downwards

on the muscle rather nearer the posterior than the anterior fold of the axilla. Forceps are applied to the lateral perforating branches of the intercostal vessels. The next step is to follow the glands upwards beneath the pectoral muscles towards the apex of the axilla. When they have been sufficiently freed they are grasped with forceps, and dragged downwards along with the axillary vein, to the sheath of which they are generally adherent. Forceps are applied to the tributaries of the vein before they are divided, and, if possible, the division should not be made too close to the main vein, otherwise the ligature is liable to slip. The removal of a portion of the axillary vein is less frequently necessary when the glands are tuberculous than it is when they are carcinomatous.

In removing the glands from the posterior wall of the axilla the subscapular vessels may have to be divided or removed; every attempt, however, should be made to preserve the long subscapular nerve which accompanies them, as it supplies the latissimus dorsi muscle.

When the subclavicular glands are extensively diseased and adherent, further access must be obtained before they can be removed. This can be got either by removing the lower fibres of the pectoralis major, or by partly or completely dividing the muscle as it crosses the axilla, and suturing it again at the close of the operation. The disadvantage of the latter plan is that the limb must be bandaged to the chest during the healing of the wound, otherwise the stitches in the muscle would cut through. It is this fixation of the arm in the adducted position which is largely responsible for the subsequent limitation of abduction.

A better plan than the above, therefore, is to remove the subclavicular glands through a separate incision made a little below and parallel to the middle two-fourths of the clavicle. The cephalic vein, which ascends in the groove between the pectoralis major and deltoid muscles, must be carefully isolated and divided between two ligatures just before it pierces the costo-coracoid membrane. The subclavicular triangular interspace between the two muscles is then freely opened up and their edges well retracted, the pectoralis major downwards and inwards, the deltoid upwards and outwards. If this does not give sufficient room some of the clavicular fibres of the pectoralis major are divided a little below their origin. The pectoralis minor is now exposed, and by dividing the costo-coracoid membrane along its upper border the muscle may be freed and retracted downwards and outwards. To reach the glands the costo-coracoid membrane must be removed and the first part of the axillary vein exposed. In doing this a blunt dissector is used to isolate the thoracic axis artery and vein, which are divided and double ligatured, care being taken to preserve the external anterior thoracic nerve, which

supplies the great pectoral muscle. Above, the glands are dissected off the sheath of the subclavius muscle, and, below it, off the upper two ribs and the fascia covering the first intercostal space. Externally, they are carefully separated from the sheath of the first part of the axillary vein, and if they are adherent the sheath must be removed along with them. Lastly, the glands are followed upwards behind the clavicle and the axillary vessels into the root of the neck. In this part of the operation they are dissected off the upper digitations of the serratus magnus and the upper part of the posterior thoracic nerve. When the dissection has been completed the two wounds freely communicate behind the pectoralis minor. Both wounds are closed completely. Drainage is provided for by introducing a tube through a puncture opening a little in front of the posterior fold of the axilla. The tube lies in the gutter between the inner and posterior walls of the axilla.

If the disease be complicated by the presence of an abscess, or a sinus, these conditions are treated on the same lines as has already been described in dealing with tuberculous glands in the neck.

EXCISION OF THE INGUINAL GLANDS

When the disease is confined to the inguinal group an incision is made parallel to and a little below Poupart's ligament, the length of the wound depending on the extent of the disease. When the femoral group is alone involved, the incision should be more or less vertical. When both sets of glands are diseased, a flap with its base at Poupart's ligament is dissected upwards off Scarpa's triangle by means of a horse-shoe-shaped incision. When the glands are not adherent their removal is a comparatively simple matter, but when they are caseous and adherent, considerable difficulty may be experienced in separating them from the long saphenous vein and from the femoral vein. In dissecting the glands off the cribriform fascia and the fascia lata, the upper part of the long saphenous vein and portions of the superficial branches of the femoral artery and their companion veins are removed along with the glands. In ligaturing the long saphenous vein close to the femoral care must be taken to see that a sufficient pedicle is left to prevent the ligature from slipping. If the femoral vein itself be wounded the whole vein should not be ligatured; the opening should be sutured with a fine needle and catgut, and the sutured area should be supported by stitching over it the remains of the sheath, or any fascia in its immediate neighbourhood.

If the gland which occupies the crural canal be also diseased, it must be removed by carefully opening up the inner compartment of the femoral

sheath, care being taken to keep the femoral vein retracted outwards. If after removing the gland the crural ring seems to be unduly patent, it should be closed according to one or other of the methods adopted in performing the radical cure of a femoral hernia. It is usually sufficient to pass a loop of catgut—or linen thread—through the whole thickness of the pectineus muscle just internal to the femoral vein, and then to pass the two extremities of the sutures from within outwards through the external oblique immediately above Poupart's ligament. By tightening up the suture, and tying the ends together, the crural canal is closed by approximating the inner part of Poupart's ligament to the pectineus muscle.

If the femoral vein has been sutured the bandage should be firmly applied and the foot of the bed should be raised. Should the vein become thrombosed the risk of embolism must be guarded against by preventing the patient from moving the limb.

SECTION I

OPERATIONS UPON THE DUCTLESS GLANDS

PART II

OPERATIONS UPON THE SPLEEN

BY

B. G. A. MOYNIHAN, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to the Leeds General Infirmary

AND

HAROLD UPCOTT, F.R.C.S. (Eng.)

Assistant Surgeon to the Hull Royal Infirmary

CHAPTER IV

OPERATIONS UPON THE SPLEEN

ANATOMY OF THE SPLEEN

THE spleen is almost entirely covered with peritoneum and is situated behind the fundus of the stomach, being covered by the lower ribs. Its outer or phrenic surface is convex and lies against the diaphragm, which

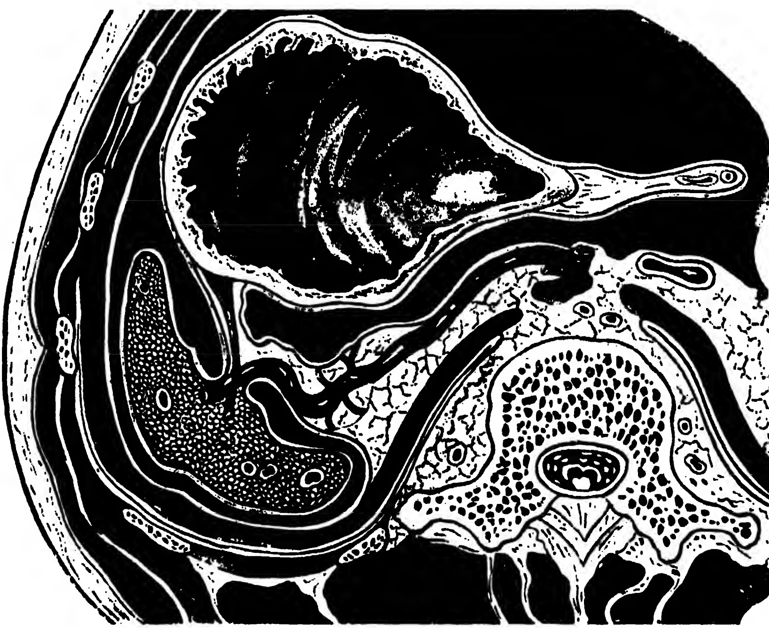


FIG. 8. THE SPLEEN: ITS PEDICLES AND BLOOD-VESSELS.

separates it from the ninth, tenth, and eleventh ribs. In its upper part it is separated from the costal wall by the left pleura and lung.

The gastric surface is concave and rests upon the fundus of the stomach. Within the confines of this surface lies the hilum for the entry and departure of the splenic vessels.

The renal surface is applied to the upper and outer part of the anterior surface of the left kidney, and usually overlaps the summit of the supra-renal capsule.

The basal end of the spleen bears a varying relationship to the splenic flexure of the colon and tail of the pancreas. The extent to which the tail of the pancreas comes into relationship with the spleen may vary considerably; it very frequently encroaches on the gastric surface in its lower part as far forward as the hilum.

The peritoneal attachments of the spleen are three :—

1. *The lieno-renal ligament*, a double fold of peritoneum which passes from the intermediate border of the spleen to the anterior surface of the left kidney.

This peritoneal attachment only partakes of the nature of a ligament when the spleen is drawn forward; *in situ*, the two folds forming it pass off to the right and to the left on the posterior abdominal wall, the tail of the pancreas and the splenic vessels separating them widely.

2. *The gastro-splenic omentum* is a longer and more delicate fold which passes from the hilum of the spleen to the fundus of the stomach; between its layers run the left arteria gastro-epiploica and the vasa brevia, branches of the splenic artery. This fold is continuous below with the gastro-colic omentum.

3. The lower end of the spleen is supported by a peritoneal shelf, the *costo-colic ligament*, formed by a fold of peritoneum passing from the diaphragm opposite the tenth and eleventh ribs to the splenic flexure of the colon.

The spleen receives its blood-supply from the splenic artery, a branch of the cœliac axis. This vessel breaks up between the layers of the lieno-renal ligament into five or six branches which enter the hilum of the spleen.

The blood returning from the spleen is poured into the portal system through the splenic vein.

The spleen may be marked out upon the surface of the body by drawing two horizontal lines from the spinous processes of the ninth dorsal and first lumbar vertebræ; these are joined by a vertical line 4 centimetres (1½ inches) to the left of the mid-line of the body, and another corresponding with the left mid-axillary line. Within this quadrilateral space the spleen lies obliquely beneath the ninth, tenth, and eleventh ribs.

EFFECTS OF REMOVAL OF THE SPLEEN

The most important changes which ensue after removal of the spleen are those which occur in the blood.

These changes are an immediate diminution of red cells and a lowering of the percentage of hæmoglobin, and a leucocytosis which, while it may last for some time, alters in character.

The number of red cells per cubic millimetre of blood generally returns to the normal in the course of a few weeks or months after operation. This anæmia is probably to be explained, at any rate in part, by the loss of blood consequent upon rupture of the spleen, or by the abstraction of so large a quantity of blood as would be contained in an enlarged spleen.

The immediate leucocytosis is due to an increase in the polymorphonuclear cells, and in several cases where it has been excessive it may be attributed to some septic complication, phlebitis, suppurative bronchitis, or infection of the wound. As this initial leucocytosis subsides, there may occur a more characteristic increase of the lymphocytes, commencing in two or three weeks coincidentally with a general enlargement of the lymph nodes. In the cases of Matthew and D'Este Emery, which were observed over periods of two and three years respectively, this lymphocytosis was maintained. In their cases a transitory eosinophilia set in early in the first year. In Lewis's case, which was studied for a period of four years before and three years after operation, there was an immediate and marked rise in the number of eosinophiles which persisted during the three years that the patient was under observation. No lymphocytosis occurred in this case, and no enlargement of lymphatic nodes was observed.

Others have recorded a marked increase in the number of eosinophiles during the second year, an observation which agrees with the results of experiments upon guinea-pigs and which has been thought to signify an assumption of activity on the part of the red marrow to replace the vicarious function of the lymphatic glands.

In many of the carefully recorded cases of splenectomy a general enlargement of the lymphatic glands has been observed. The work of Warthin upon the sheep and goat seems to have established the fact that the lymphatic glands take upon themselves a part at least of the work normally done by the spleen. Many patients have made complaint of pain and tenderness in and along the bones of the limbs after splenectomy. This, it may be, is due to the changes, probably of a compensatory nature, which have been shown to take place in the bone marrow. In certain recorded cases pyrexia, rapid pulse, emaciation, drowsiness, and abdominal pain have been noted, but these symptoms do not appear to be at all constant.

It has been suggested, and to some extent experimental work supports the opinion, that after removal of the spleen the individual is more susceptible to an infection. On the other hand, clinical observation seems to show that the patient's powers of resistance, as evidenced by the prompt development of a polymorphonuclear leucocytosis in response

to infection, is in no way lessened. The loss of the spleen does not appear to influence metabolism, and the operation has been performed upon pregnant women who have thereafter gone to full term.

Vulpius states that the regeneration of blood after a severe hæmorrhage is probably slower and feebler in those who have lost the spleen. On the whole, however, experimental and clinical work has demonstrated that the spleen is an organ which is not essential to life or to health.

SPLENECTOMY

Indications. (i) *Injury.* The spleen may be injured by penetrating wounds or may suffer laceration or crushing in the absence of perforation of the parietes. In the great majority of these cases the extent of the laceration is such that splenectomy is the most efficient and rapid method of controlling hæmorrhage. Even in those cases of slight capsular rupture met with in chronically enlarged or wandering spleen, the result of minor degrees of violence, splenectomy is indicated, though either the slight tearing of the capsule or the size of the organ might not, in themselves, warrant such radical treatment. In the rare forms of injury in which the spleen, wounded or uninjured, escapes through a rent in the abdominal wall, it is wiser in most cases to perform splenectomy on account of the dangers of reposition, from an overlooked laceration or from sepsis.

(ii) *Abscess.* Johnston has recorded nine splenectomies for abscess with one death, and although in some cases where the splenic abscess is found after the abdomen has been opened for exploratory purposes the organ may be excised, as a rule incision and drainage are the best procedures (see Splenotomy).

(iii) *Tuberculosis.* In primary enlargement of the spleen from tubercle, and in secondary affection, when the organ is giving rise to trouble by reason of its mobility, splenectomy is an operation which has given satisfactory results.

(iv) *Cysts.* Of the three varieties of this condition, hydatid cysts, non-parasitic cysts, and dermoid cysts, the last mentioned is of extreme rarity. Provided the adhesions are not too extensive, splenectomy is undoubtedly the operation to be preferred.

(v) *New growths.* Primary growths of the spleen should be treated by splenectomy. They are extremely rare.

(vi) *Primary splenomegaly.* There is a simple hypertrophy of the spleen unattended by any marked or constant changes in the blood or by any notable symptoms except those directly due to the bulk of the tumour. Splenectomy is called for in these cases only when the spleen attains such a size that it causes serious inconvenience, or for relief of acute torsion of

the pedicle. It should be remembered that these enlarged spleens, and also those coming under the next heading, are liable to rupture or laceration as the result of very slight injury; splenectomy is, therefore, justified as a prophylactic measure. The enlarged spleen of malaria should only be removed for the same reasons.

(vii) *Splenic anæmia.* Under this term are included those cases of chronic splenic enlargement for which no known cause is discoverable, which show an anæmia of the secondary type, though the colour index may be disproportionally low, a leucopenia, or at least an absence of any increase in white cells, and a tendency to hæmorrhages, especially from the gastro-intestinal tract. Surgical advice is likely to be sought for the relief of the two conditions: the inconvenience caused by the size of the tumour and the recurrent hæmorrhages. Recorded cases seem to show that the removal of the spleen in the early stages of splenic anæmia, before the onset of the terminal hepatic cirrhosis and ascites, holds out a good prospect of cure, and that at this stage the risks of the operation are slight.

In the later stages there are greater dangers attaching to the operation, not only on account of the tendency to hæmorrhages but also from the adhesions, which may render the operation one of great difficulty. In a few cases, however, the operation has been undertaken at a late stage, after the development of ascites.

Tansini in such circumstances performed splenectomy and epiplopexy; four weeks later the abdomen had to be tapped, but the patient recovered and remained well up to the time of the report several months later.

(viii) *Wandering spleen.* When surgical treatment is required for this condition, splenectomy is usually the most appropriate operation, for it is not often that the slighter degrees of movable spleen, those most suitable for replacement of the organ in its normal position, give rise to sufficient inconvenience to call for operation. When the pedicle is long, when the spleen is engorged or adherent in its false position, then splenectomy is the better practice.

Contra-indications. (i) Though desirable on other grounds, splenectomy may be contra-indicated on account of the density of the adhesions enveloping the spleen. This state of affairs cannot be anticipated, consequently the line of treatment will depend upon the conditions for which the operation was undertaken; for example, tamponnade of a lacerated spleen or drainage of a cyst.

(ii) Excision of the leukæmic spleen is totally unjustifiable; it has no beneficial effect on the course of the disease, while it has given a heavy primary mortality.

(iii) The enlarged spleen of malaria should not be excised except under the conditions already mentioned.

(iv) Portal hepatic cirrhosis associated with enlarged spleen, ascites, and gastro-intestinal hæmorrhages has undoubtedly been mistaken for Banti's disease and been treated by splenectomy on this assumption.

Operation. The abdominal incision may be vertical, either in the mid-line or at the outer margin of the rectus, or it may be oblique, following the costal margin. The median incision gives good exposure when the spleen is markedly enlarged or freely movable; it is also the best incision when the diagnosis is uncertain, and has the advantage, in traumatic cases, of permitting a search for other wounded viscera. If necessary, a transverse cut may be added to it at the level of the lowest part of the costal border. The lateral vertical incision, though more directly over the spleen, has the disadvantage of allowing less freedom of access to the dome of the diaphragm. The oblique incision is favoured by Vanvert and Auvray, who also resect the costal cartilages of the eighth, ninth, and tenth ribs. The incision, wherever placed, should be of adequate length to allow a perfectly clear view of the operation field, and to render it unnecessary to have any force applied to the spleen or its adhesions to bring them into sight.

In cases of rupture the first step is to control the bleeding; this is best done by grasping the pedicle. In other cases the surgeon proceeds at once to the separation of adhesions. This must be done with the utmost care and patience, the adhesions being isolated in turn and divided between ligatures, thus working steadily until the gland is free. When the omentum is firmly adherent it is better to divide it between ligatures at some little distance away from the spleen than to attempt to separate the adhesions.

After freeing the spleen attention must be turned to the pedicle. The spleen is carefully brought up into the wound, an assistant at the same time depressing the edges of the incision in order to prevent any traction on the pedicle which might easily result in rupture of its thin-walled vessels.

Ligature of the pedicle is the next step in the operation. If speed be a matter of prime importance, a stout ligature should be thrown round the pedicle, which is ligatured *en masse*, all tension on the spleen being relaxed at the moment of tying the knot. When removing the spleen for disease, the pedicle should be secured with greater deliberation. This is especially necessary when the spleen is enlarged and its vascular supply correspondingly increased, or when, owing to torsion of a long pedicle, its vessels are engorged.

Whenever it is possible an interlocking ligature is to be preferred. The

pedicle is carefully pierced, between the vessels, by the blunt nose of a pair of forceps which are then withdrawn, carrying with them a looped ligature. The loop is cut and the ends crossed, each half of the pedicle being then secured in turn. An additional ligature is finally applied to the whole thickness of the pedicle and the spleen removed.

If the vessels be very large they may be isolated by the blunt dissection with the finger covered with gauze and then divided separately after ligature in two places.

A simple method of securing the vessels is the following: A large stomach clamp is applied to the pedicle as close to the spleen as possible. Then about $1\frac{1}{2}$ inches away a series of clips is applied from below upwards. As each clip is applied the pedicle is cut through between it and the large clamp. When all the clips, three, four, five, or even more in number, are applied, a long ligature is taken, tied round the portion of the pedicle included in the uppermost clip, the clip is loosened slowly and removed, a double knot tied, then the next clip is raised and the same ligature, without division, is passed round it, tied, the clip removed, and so on as before. Every part of the pedicle is thus included in one ligature, which is knotted in between each clip. For the ligature stout catgut or Pagenstecher's thread may be used.

The ligature should always be thick, otherwise the flimsy vessel-wall may be cut through. In some cases the tail of the pancreas has accidentally or deliberately been included in the ligature surrounding the pedicle, in order to ensure a firmer hold. Esmarch advises that this should be done if there is any doubt as to the security of the ligature.

Bland-Sutton has remarked on the fact that the enlarged spleen may shrink—in his case to one-third of its original size—during the course of the operation for its removal.

In a few cases sudden symptoms of shock have been observed when the pedicle was clamped or divided, owing to irritation of the nerves of the solar plexus.

After the spleen has been removed the cavity left must be carefully examined, and any slightly oozing point secured. The under surface of the diaphragm, especially, must be examined, and any bleeding point thereon secured by a stitch.

Where the operation has been undertaken for bullet or stab wounds a careful search for wounds of other viscera should now be made, and always before closing the abdomen the pedicle should be finally inspected.

Dangers. In a case of injury to the spleen the gravity of the operation depends more upon the amount of the previous hæmorrhage, the degree of shock, and the associated injuries to other viscera than upon the operation itself. There is, however, a special danger, after splenec-

tomy, from hæmorrhage due either to slipping of the ligature around the pedicle or from unligatured adhesions divided during the operation; this is less likely to occur after deliberate operation for disease than after the frequently hurried operation of urgency for rupture.

More serious results of splenectomy are thrombosis of the splenic vein leading to thrombosis of the superior and inferior mesenteric veins and gangrene of the intestine, and interference with the blood-supply of the fundus of the stomach. The latter injury is probably the cause of the severe hæmatemesis sometimes following the operation, and is to be avoided by careful ligature of the gastro-splenic omentum as close to the spleen as possible.

Results. The later results of splenectomy upon the organism have been already discussed. The immediate mortality in cases of diseased spleen depends upon the condition for the relief of which the operation was performed. Thus, for such a purely local condition as non-parasitic cysts, of which Bircher has collected 33 cases, 15 were treated by splenectomy without a death, and Johnston has brought the total up to 19 splenectomies with no mortality. Splenectomy for hydatid cysts shows a mortality of about 17%, while after removal of the spleen for Banti's disease and primary splenomegaly there is a mortality of about 19% and 28% respectively.

SUTURE OF A RUPTURED SPLEEN

Indications. If the tear in the spleen be but slight, and the patient's condition does not call for the most rapid method of treatment, an attempt may be made to suture the wound and save the organ.

Operation. Stout catgut is the best material to use, and the sutures should be passed some distance from the edge of the laceration. If the gland proves very friable the linked mattress suture devised by Nuzum may be used. It is introduced as follows: Pass a long needle armed with coarse catgut straight through the spleen about half an inch from the cut edge, cross over the incision to an equal distance on the opposite side, and to a point corresponding to the one of exit, and pass straight through in the opposite direction. Then carry the needle three-quarters of an inch from the last point of exit on the same side of the incision and pass back again through the spleen. Then cross the incision as before, but in the opposite direction, and emerge on the same side of the incision as the needle first entered and directly opposite the point where the needle entered the opposite side. Tie the ends loosely together. The suture is then passed under the strand opposite to where the knot is tied, thus linking two parallel strands across the incision. When this is tied the cut surfaces are brought together and hæmorrhage is arrested.

Suture has been generally combined with gauze packing and drainage.

Nicholas Senn, in discussing traumatic hæmorrhage from the spleen, suggests that crushing the margins of the wound in the spleen should be adopted. Experimentally, he found that marginal crushing always arrested the hæmorrhage from splenic wounds completely. Large forci-pressure clamps were applied to each side of the wound ; bleeding stopped at once, and the opposite surfaces were brought together by a few catgut stitches. He deprecates the ready recourse to splenectomy which is prevalent, and points out that the compensatory mechanism after splenectomy may not always be satisfactory.

Results. Schäfer records 11 cases in which the wound of the spleen was closed by suture, and in 9 recovery followed. Splenectomy was performed in 10 cases, only 3 recovering. To these Laspeyres adds 8 cases of splenectomy for stab and bullet wounds, 5 dying and 3 recovering. As these figures take no account of the severity of the injury, and as it is certain that only the lesser injuries would be treated by suture, the only deduction to be drawn from them is that in such cases suture of the spleen is a safe line of treatment.

SPLENOTOMY AND MARSUPIALIZATION

Indications. (i) Abscess.

(ii) Cysts. Splenotomy and marsupialization is the most satisfactory operation in those cases where the number and complexity of adhesions render more radical measures unsafe, more especially in hydatid cysts, which occur oftener in the upper pole of the spleen. The great drawback of this treatment is the length of time required for healing.

Operation. (i) **For abscess.**

The incision is made directly over the point of greatest tenderness. In most cases in which a diagnosis of splenic abscess has been made the spleen will be found adherent to the abdominal wall; if this be found to be the case the abscess is opened at once and drained. If, on opening the abdomen, the spleen be found to be non-adherent to the parietal peritoneum, the wound should be packed with gauze and the opening of the abscess deferred for two days.

There are cases in which the transpleural route is preferable, portions of one or more ribs being excised and the diaphragm cut through. This should be performed in two stages, the first operation being limited to exposure of the diaphragm and suture to the parietal pleura.

(ii) **For cysts.**

If the spleen be adherent to the parietes the operation may be performed

in one stage, the cyst being evacuated and the cavity packed with gauze. If the cyst be non-adherent its most bulging portion should be sutured to the edges of the peritoneum ; it may then be opened at once ; or better, if due to echinococcus, or if there be any doubt as to the sterility of its contents, left until the peritoneal cavity has become shut off by adhesions.

Results. Landelius has collected 14 cases of non-parasitic cyst treated by simple incision and drainage, of which number 11 recovered. Two of the three deaths occurred before the year 1880.

RESECTION OF THE SPLEEN

Indications. This operation is practically limited to those cases of non-parasitic cyst involving the lower pole of the spleen. When the cyst has so dragged on the splenic tissue as to lead to the formation of a pedicle, resection constitutes the ideal treatment.

Operation. In those rare cases of splenic cysts where resection is considered preferable to removal of the whole organ, the interest chiefly lies in the method of securing control of the bleeding after the diseased portion has been excised or enucleated.

Hæmostasis is most effectually attained by securing apposition of the raw surfaces of the spleen. With this object in view the resection should be carried out in such a manner as to leave a wedge-shaped area or gutter in the spleen, the lips of which may be held firmly together with heavy catgut sutures, each including a large amount of splenic tissue in its grasp. Fortunately the capsule of the spleen in these cases is commonly toughened by chronic perisplenitis.

SPLENOPEXY

Indications. The fixation of the wandering spleen is indicated in a certain number of cases where the organ is, apart from its mobility, apparently normal. In the majority of cases the elongation of the pedicle is either secondary to enlargement of the spleen, or else it leads to such interference with the blood-supply that the organ becomes chronically congested or is subject to attacks of acute engorgement.

Operation. Splenopexy may be performed in several ways, but the best methods are those in which the spleen is fixed, partially or wholly, in an artificial space beneath the peritoneum.

Rydygier's method. The incision is made in the middle line or through the outer margin of the left rectus. The diaphragm is exposed, and a transverse incision between the ninth and tenth ribs is made. The peritoneum above and below this incision is raised up by the finger

until a pocket on each side is formed. To do this below is easy, but on the upper side the adhesion to the diaphragm is so close that the peritoneum is apt to tear away. A continuous suture (or a series of interrupted sutures) is now applied around the upper and lower margins of the pocket, so as to limit the cavity formed by the raising up of the peritoneum. The spleen is then placed in the pocket formed for it.

FIG. 9. SPLENOPEXY BY RYDYGIER'S METHOD. *The incision in the peritoneum.*

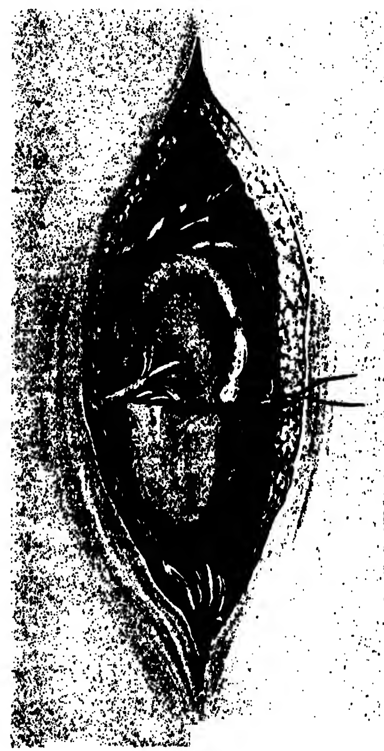


FIG. 10. SPLENOPEXY BY RYDYGIER'S METHOD. *The spleen in position.*

Bardenheuer's method. The patient lies upon the right side as for an operation upon the left kidney. A longitudinal incision is made in the axillary line, reaching from the tenth rib to the iliac crest. At the upper end of this a transverse incision is added to give additional room. The soft parts are divided down to the peritoneum, which is stripped up over an area rather larger than the area of the spleen. The peritoneum is then incised, the opening being made of as small a size as will allow the passage of the spleen through it. The spleen is sought and found and drawn

through the opening in the peritoneum. The size of the opening is then lessened by a few points of suture, and the wound in the parietes closed. The spleen by this operation is brought to lie altogether outside the peritoneum.

Basil Hall's method. This operation is described by its author in the following words: 'The abdomen was opened by an incision at the outer border of the left rectus abdominis. The lower pole of the spleen was exposed by this incision, and the whole organ was then delivered through

FIG. 11. SPLENOPEXY BY BASIL HALL'S METHOD.

it without much difficulty. Except for its size it was, to all appearances, a normal spleen. While considering the advisability of removal, however, it was noticed that the notch on the anterior border was only 2 or 3 inches from the lower extremity of the spleen, and the depth of the notch was such that the lower pole of the spleen was only connected to the rest of the organ by a comparatively narrow isthmus. This arrangement at once suggested an easy means of fixing the organ. The main body of the spleen

was, therefore, replaced in the abdomen, after rendering the parietal peritoneum raw in the splenic fossa in order to excite adhesions. Then, while the lower pole was held in the wound, the edges of the peritoneum were drawn tight by a purse-string suture until they closely gripped the narrow isthmus in the notch. The abdominal aponeurosis was next sutured in a similar manner until it grasped the isthmus in the notch sufficiently tightly to produce a marked congestion of the now isolated lower pole. The left rectus muscle was next drawn outwards somewhat, so as to overlap the projecting pole of the spleen as much as possible, and the skin incision sutured.'

It is evident that this method of operation will not often be feasible.

Bibliography

Ballance. *Clin. Soc. Trans.*, 1896, xxix. 77.
Berger. *Archiv f. klin. Chir.*, lxviii. 865.
Bessel Hagen. *Archiv f. klin. Chir.*, 1900, lxii. 212.
Bircher. *Deut. Zeit. f. Chir.*, 1906, xcii. 323.
Bland-Sutton. *Brit. Med. Journ.*, 1897, i. 132.
D'Este Emery. *Lancet*, 1907, i. 1696.
Goodall. *Journ. Path. and Bact.*, 1904, ix. 400.
Hall. *Ann. of Surg.*, 1903, April.
Johnston. *Ann. of Surg.*, 1908, xlviii. 50.
Landelius. *Nordd. med. Archiv. (Chir.)*, 1908, xli. 1.
Laspeyres. *Centralbl. Grenzgebiet.*, 1904, vii. 152.
Lewerenz. *Archiv f. klin. Chir.*, 1900, lx. 951.
Lewis. *Amer. Journ. Med. Sci.*, 1908, cxxxvi. 157.
Lyon. *Journ. Path. and Bact.*, 1904, ix. 400.
Martin. *Archiv. gén. de Chir.*, 1908, ii. 7.
Matthew and Miles. *Edin. Med. Journ.*, 1907, xxii. (N.S.) 294.
Nuzum. *Railway Surg. Journ.*, 1907, May (quoted in the Gen. Surg., Pract. Med. Series, 1908, 525).
Schäfer. *Beitr. zur klin. Chir.*, 1902, xxxvi. 3.
Senn. *Journ. Amer. Med. Assoc.*, 1903, xli. 1241.
Simpson. *Lancet*, 1906, ii. 364.
Torrance. *Ann. of Surg.*, 1908, xlvii. 41.
Vulpius. *Beitr. zur klin. Chir.*, 1894, xi. 33.
Warthin. Contrib. to Med. Research, *Ann. Arbor Univ., Michigan*, 1903, 234; *Amer. Journ. Med. Sci.*, 1902, cxxiv. 764.

-

SECTION I

OPERATIONS UPON THE DUCTLESS GLANDS

PART III

OPERATIONS UPON THE THYREOID GLAND

BY

JAMES BERRY, B.S. (Lond.), F.R.C.S. (Eng.)

Senior Surgeon to the Royal Free Hospital; Surgeon to the Alexandra Hospital for Children with Hip-disease

CHAPTER V

PUNCTURE: INJECTION: INCISION: LIGATURE OF THE THYREOID[1] ARTERIES: EXOTHYREOPEXY

In this chapter certain operations of very limited applicability will be described. Most of them will be performed only under conditions in which the technical skill and knowledge of aseptic surgery necessary for the performance of the larger and more satisfactory operations upon the thyreoid gland are not available.

PUNCTURE

Indications. Puncture of the thyreoid gland is occasionally demanded either as a diagnostic or as a curative measure.

(i) *As a diagnostic measure* it may occasionally be employed to detect the existence of fluid. But encapsuled tumours of the thyreoid, which alone contain fluid in any quantity, can be diagnosed readily enough by other means, and chiefly by their shape, without resorting to puncture. Once the diagnosis of an encapsuled tumour has been made, it is a matter of little importance whether its contents be wholly solid or wholly or partly fluid, since in any case the proper treatment for it, if any treatment at all be required, is enucleation.

The chief objection to puncture is, that it is likely to cause hæmorrhage. This may take place from the plexus of large veins lying on the surface of the thyreoid gland. These veins, lying as they do behind the infrahyoid muscles, cannot be seen, and it is impossible for the operator to know exactly where they are; therefore he cannot avoid them as he can the more superficial and visible veins belonging to the anterior jugular system. Hæmorrhage from these thyreoid veins takes place into the cellular tissue of the neck and may be serious.

An even more serious source of hæmorrhage is the adenomatous tissue that is nearly always present within a thyreoid cyst. Bleeding from this is easily caused by the trochar or by the collapse of the cyst consequent upon the evacuation of fluid. Blood may thus accumulate within the cyst and distend it to such an extent that alarming and even fatal dyspnœa may ensue. Or blood may continue to escape through the puncture hole either externally or into the cellular tissues of the neck.

[1] This method of spelling, in conformity with the Basle Nomenclature of Anatomy, has been adopted throughout this and other articles. -Ed.

The writer has known several cases in which the patient's life has been seriously threatened or even lost by injudicious tapping of a thyreoid cyst.

(ii) *As a curative measure* simple puncture is seldom satisfactory. In the case of a small cyst with a thin wall permitting collapse of the empty cyst, a permanent cure may follow. But more often the cure is but temporary and the fluid reaccumulates.

If the cyst contains much solid adenomatous material complete cure is impossible. If the wall be thick and unyielding, no benefit will accrue from the puncture, and it is not unlikely that a permanent fistula will be the result. The dangers of hæmorrhage have already been mentioned. That of sepsis is also a very real one, especially if the puncture lead to a more or less permanent opening discharging blood or colloid.

Since the introduction of improved methods of operating upon thyreoid tumours, puncture has fallen out of fashion and is now but seldom performed. It is, however, occasionally resorted to in exceptional cases, more especially when the circumstances of the case preclude the performance of the usually more satisfactory open operation.

Operation. A fine trochar and canula or a small aspirating syringe should be employed. The most prominent part of the supposed cyst should be selected, and a spot should be chosen which is free from visible superficial veins. The point of the trochar should be directed to the centre of the tumour. The fluid should be withdrawn very slowly. If the puncture be for diagnosis only, it is best to withdraw only a very small quantity of fluid, so as to minimize the risk of intracystic hæmorrhage.

INJECTION

Indications. This proceeding, like simple puncture, is but seldom to be recommended. It is uncertain in its results and by no means free from danger.

It has been employed both for parenchymatous goître and for cysts.

The object that is aimed at in the injection of a goître is to cause sufficient inflammation to obliterate some of the minute vesicles of a parenchymatous goître or the larger cysts of a cystic one. It is obvious, therefore, that the harder and more solid forms of goître are quite unsuitable for this method of treatment. It should never be employed in any case in which serious dyspnœa is present.

Operation. The materials that have been used for injection are numerous. That which occupies the foremost rank is undoubtedly iodine. This may be used in the form of simple tincture or in combination with other drugs. Arsenical solutions, perchloride of iron, ergot,

osmic acid, and iodoform have all had their advocates, but probably none of them is superior to iodine.

INJECTION OF PARENCHYMATOUS GOÎTRE

The best directions for the performance of the injection of iodine into parenchymatous goître are those of Sir Felix Semon, who has written as follows :—

'1. Select suitable cases only, *i.e.* cases in which the gland substance is so thick that one may be fairly certain that the injection can be made into the parenchyma proper, and in which, on the other hand, the interstitial fibroid change has not progressed too far.

'2. Inject every third day into the gland substance proper a quantity, from twenty to thirty drops, of an alcoholic iodine solution (one part of iodine in twelve parts of absolute alcohol) with a well-made and well-cleaned hypodermic and screw syringe.

'3. Vary as much as possible the place of injection, and never inject into the same neighbourhood on two consecutive occasions.

'4. Avoid wounding superficial veins and injecting air. A piece of tape may be tied round the neck below the tumour so as to compress the superficial veins.

'5. Neither insert the point of the needle too timidly, when the injection fluid will very likely pass into the cellular tissue, suppuration resulting; nor too violently, when it may completely perforate the gland and the injecting fluid may be thrown into other important tissues. It is a good plan to let the patient swallow when the needle has been inserted, before the injection is proceeded with, the body of the syringe being held quite loosely in the operator's hand ; if the point of the needle is in the gland substance the foremost point of the syringe will rise with the rising gland ; if it be in front of the gland no movement will ensue ; if it have perforated the gland the hindermost part of the syringe will chiefly rise.

'6. Never inject in such a direction that the point of the needle points directly towards the trachea or towards the great vessels and nerves of the neck.

'7. Inject very slowly and watch especially the effect of the injection of the first few drops. Select the place of injection carefully beforehand by palpation and steady the tumour with the left hand whilst making the injection. Previous freezing of the surface with anæsthetic ether round the point selected for injection may be resorted to, but is not necessary.'

INJECTION OF CYSTS

For those who desire to employ this exceedingly dangerous method of treatment, the directions given by the late Sir Morell Mackenzie may

be quoted, but the practice is not recommended except possibly under very exceptional circumstances.

An operation which depends for its success upon the establishment of suppuration within the thyreoid is not one which is likely to meet with much favour at the present day. Its solitary claim to recognition is the small size of the scar that is produced by it.

'The cyst is first punctured and emptied with a trocar at its most dependent part, a drachm or two of the solution of perchloride of iron [1] is then injected, the canula with its plug and the iron solution being left in the cyst. After twenty-four hours the plug is removed, and the contents of the cyst withdrawn. If the fluid be then found to contain much blood, or if it be thin and serous in appearance, a second injection must be made. In other words, while hæmorrhage must be carefully prevented, a slight inflammation of the lining membrane of the cyst is essential. One injection is generally sufficient, but if the first injection fluid be too quickly removed, the process may have to be repeated three or four times at intervals of two or three days. When reaction has taken place, and the discharge is free from blood, the canula with its plug must still be kept in the cyst. Poultices of linseed meal should be kept constantly applied for three or four weeks, sometimes longer. When suppuration is well set up the plug may be removed; the canula, however, being allowed to remain until the secretions become limited in amount and thin in consistence. When the cyst is very large it is best to try to reduce the quantity of fluid before injecting. This can often be done by drawing off a small amount, say two or three drachms, at intervals of a day or two on several occasions. No attempt must, however, be made to empty the sac entirely, for if this is done hæmorrhage takes place from the lining membrane of the cyst into its cavity, which soon becomes full again. The duration of the treatment is from three weeks to four months, according to the size of the cyst, the usual time being six to eight weeks.'

Results. *As regards parenchymatous goitre* there is no doubt that in many cases a more or less successful result ensues, at any rate for a time. There is, however, equally little doubt that very often the treatment is unsuccessful. A considerable number of cases have been recorded in which various complications, including death itself, have followed the operation. The injection may, and in most cases probably does, at first produce increased swelling of the gland. This may cause dyspnœa or aggravate that which is already present. The injection may cause suppuration, which in its turn may easily lead to death.

[1] A watery 25 % solution of perchloride of iron is used.

As regards the injection of cysts with perchloride of iron, similar remarks apply. A complete cure more often follows, but, on the other hand, the dangers of hæmorrhage and sepsis are much greater. The risk of the supervention of a permanent fistula is considerable.

The operator who undertakes to inject a thyreoid cyst must be prepared for grave complications, which may demand serious measures, such as laying open and packing the cavity or even enucleation of the inflamed or suppurating cyst. Both of these operations are highly dangerous under these conditions.

INCISION

Indications. Except for some acute inflammatory conditions simple incision is rarely desirable. As an exploratory operation it is occasionally justifiable in certain cases of doubtful malignant disease. Incision of a thyreoid cyst is occasionally performed when its fixity is such that enucleation cannot be advised.

In such cases the cut edges of the cyst may be sewn to those of the skin, the cavity being packed with gauze and drained. The risks of such an operation are, however, considerable, and a permanent fistula is not unlikely to follow.

Incision of the isthmus of the thyreoid gland is sometimes performed in cases of parenchymatous goître with a moderate degree of dyspnœa. It is not to be recommended if a high degree of dyspnœa be present, since the operation is often followed by a certain amount of inflammatory swelling, which may cause the already narrow scabbard-shaped trachea to be compressed still more. This may lead rapidly to death by suffocation. Sometimes division of the isthmus leads to separation of the previously united lateral lobes, and thus frees the trachea at once from lateral pressure. More often the incision merely allows the accumulated colloid to drain away slowly, and thus causes diminution in the size of the goître. Recurrence is not uncommon as the wound heals and the colloid reaccumulates.

In some cases of otherwise inoperable malignant disease attacking a parenchymatous goître, temporary but marked relief may be afforded to the respiratory distress by a linear incision down to the trachea. In such a case it is the draining away of the colloid that relieves the pressure.

It is in cases of acute suppuration, however, that incision is most useful and most often demanded.

When the diagnosis of localized suppuration within the thyreoid gland has been made, no time should be lost before cutting down upon the abscess and evacuating the pus.

OPERATION FOR ABSCESS

A direct incision should be made over the most prominent part of the inflammatory swelling and carried down into the gland until the pus is reached. If the abscess be deeply seated, the operator must be prepared to meet with considerable hæmorrhage. Large vessels may require ligature, and it will generally be found necessary to pack the cavity with gauze. Provision must be made for free drainage.

If suppuration occurs in a thyreoid cyst as the result of injection, the cyst should be laid freely open and packed with gauze. Occasionally under these circumstances, enucleation of the cyst (see p. 80) is a preferable proceeding. The same may be said of suppuration of an adenoma. As a rule, however, in dealing with acute suppuration in the thyreoid, the less the operator does the better. He should content himself, for the time at least, with providing a free exit for the pus.

The diffuse suppuration which occasionally occurs in large solid goîtres as the result of injection is a most serious condition. It is very likely to lead to death from suffocation or from sepsis. It may exceptionally demand some large operation, such as extirpation or enucleation, if life be seriously threatened by urgent dyspnœa.

LIGATURE OF THE THYREOID ARTERIES

This operation has been recommended and performed many times in the hope that by cutting off the blood-supply to the goître, its size might be diminished. Originally performed by Walther of Landshut and others as long ago as the beginning of the nineteenth century, for many years it was completely out of fashion and was never performed.

Of late years its use has been revived by Wölfler and Billroth, who recommended that not only the superior but also the inferior thyreoid arteries should be tied. Still more recently its use has been recommended by Kocher, more especially for cases of exophthalmic goître. The writer has practised it several times, but does not consider it to be, in itself, a good operation.

Indications. (i) *For parenchymatous goître* it has often been employed, but there is no evidence that it has any beneficial effect upon the goître. Ligature of the superior thyreoid arteries alone is quite useless.

Ligature of the inferior thyreoid arteries is usually a difficult and somewhat dangerous operation, and there is no evidence that it is of any real value in the treatment of this disease. In cases of small parenchymatous goîtres it is unnecessary, and in the case of large ones it is almost as severe a proceeding as removal of part of the goître, and gives far less satisfactory results.

(ii) Its use at the present day is restricted to *exophthalmic goître*,

and is not often to be recommended even for this disease. In bad cases of this disease where the operator hesitates to remove a lobe of the gland, it is sometimes desirable to tie one or more thyreoid arteries as a preliminary measure before proceeding to the more radical operation. The writer has in his own practice seen marked benefit follow ligature of both superior arteries and one inferior artery in a very bad case of exophthalmic goître. He considers it, however, to be a dangerous proceeding, and is of opinion that in acute cases it should never be employed. In certain chronic cases it may be worth trying.

Operation. *Ligature of the superior thyreoid artery* is best performed through an incision along the anterior border of the sterno-mastoid opposite the great cornu of the hyoid bone. The artery may be tied either near the tip of the great cornu of the hyoid or at the inner edge of the omo-hyoid muscle. The latter method is said to be the better when the goître is large and the artery consequently much displaced. The apex of the upper horn of the gland is naturally a good guide to the vessel.

Ligature of the inferior artery is much more difficult. This operation may be performed by one or other of three principal methods.

1. Internal to the sterno-mastoid (Velpeau's method). An incision is made along the anterior border of this muscle. The veins passing from the thyreoid gland to the internal jugular vein are tied and divided. The carotid sheath is drawn outwards away from the gland. The thyreoid artery is then found at the inner border of the scalenus anticus muscle. The artery should be tied just where it changes its direction from the vertical to the horizontal.

This operation is usually difficult. Many veins have to be tied. The artery is much overlapped by the goître. The latter has to be lifted up out of its bed before the artery can be exposed.

2. Through the sterno-mastoid (Langenbeck's method, modified by Wölfler). The incision is made over the sterno-mastoid. Its lower end is at the junction of the inner sixth of the clavicle with the remainder. The fibres of the muscle must be partially divided. Several large veins, including the external jugular, usually require ligature. Search is now made for the tendinous part of the omo-hyoid, an important guide to the artery. The tendon is drawn upwards or divided. The carotid sheath is drawn inwards, the phrenic nerve outwards. The artery is then seen lying at the inner edge of the scalenus anticus. If necessary, this muscle must be drawn a little outwards.

3. External to the sterno-mastoid (Drobnik's method, as practised by Rydygier). This appears to be the best method, at any rate for cases in which the gland is much enlarged.

The incision is made at the posterior border of the sterno-mastoid. It begins at the clavicle or a little above it and is carried upwards to the point at which the external jugular vein crosses the posterior border of the sterno-mastoid, usually on a level with the lower border of the thyreoid cartilage. The sterno-mastoid muscle and carotid sheath are drawn inwards and the artery found as above. It is best tied immediately above the place where it is crossed by the omo-hyoid muscle.

Rydygier has proposed a slight modification of Drobnik's original operation. He makes the skin incision not vertically, but horizontally, a little above the clavicle. By this means the scar is rendered less visible.

It is not wise to attempt to ligature the inferior thyreoid by Drobnik's or Rydygier's methods without preliminary practice upon the dead body, as the artery lies at a considerable depth in close relation with many important structures.

EXOTHYREOPEXY

This operation consists in cutting down upon the thyreoid gland, dislocating it through the wound, and then leaving it exposed to the air.

It has a twofold object, that of mechanically relieving the tracheal pressure and that of inducing atrophy of the exposed gland.

First practised by Jaboulay of Lyons in 1892, the operation has been performed much more often in France than in any other country. In this country exothyreopexy has not become popular, and it does not seem at all likely that it ever will.

Indications. The operation has been performed upon various kinds of goître. It appears to have been performed most often upon, and to be most suitable for, the more solid and vascular forms of parenchymatous goître and exophthalmic goître. It is intended to obviate the risks of extirpation of such goîtres. The proceeding has, however, risks of its own, and the objections to it are considerable and obvious.

The principal objections to exothyreopexy are the mechanical difficulties of effecting the dislocation in cases in which the goître is deeply seated and causing much dyspnœa, the risk of venous hæmorrhage and sepsis, the long time occupied by the healing process, the liability to recurrence, and the very considerable deformity which is necessarily produced by the operation. The cases in which it is most likely to be justifiable seem to be those of prominent and bilateral goîtres of a parenchymatous nature, in patients who are not suffering urgently from dyspnœa, and who do not object to the unsightly appearance of the resulting scar.

It may perhaps be justifiable in certain unusual forms of *prominent* exophthalmic goître of large size.

It has also the advantages of being usually a short operation and one which requires very little of that exact knowledge of anatomy so essential for the successful performance of extirpation.

Operation. A median incision of suitable length is made in the middle line of the neck. This should extend downwards as far as the episternal notch. Any large superficial veins that may be encountered are clamped, cut, and tied. The incision is carried through the skin, fascia, and layers of cellular tissue, until the capsule of the gland has been exposed. The wound is then enlarged with the fingers, which are insinuated gently between the surface of the goître and the superficial tissues until the lateral borders of the goître have been reached. At this stage no instruments should be used for fear of tearing or cutting veins and other important structures. If, owing to the size of the goître, the fixity of the structures over it, or any other reason, the edges of the goître cannot easily be reached with the fingers, the operator must not hesitate to divide transversely the skin and muscles, so as to give more room. Each lateral lobe of the goître has now to be dislocated forwards. This is effected by hooking one or more fingers round the external border of the lobe and then drawing it forwards. As a rule each lateral lobe must be dislocated separately, one after the other. Occasionally it is possible to dislocate both lobes simultaneously by widely opening the wound with the thumbs, while pressure is exerted upon the back of the lobes by fingers placed upon the skin at the sides of the neck. This proceeding, however, exposes the trachea to serious risk of dangerous or even fatal compression. The moment of effecting the dislocation, even of one lobe, is always a dangerous one, owing to the increased pressure exerted upon the trachea. The greatest care should be taken that the thyreoid gland itself or the thyreoid veins be not torn by the fingers. The fingers should be inserted at the sides of the gland, and not beneath its lower horn, where the veins are usually large and numerous. The fingers must never penetrate the thyreoid capsule. The goître having been dislocated, strips of sterilized gauze are now packed round the tumour in the cleft between the goître and the edges of the skin wound. An antiseptic dressing is then placed over the whole of the exposed surface of the goître.

After-treatment and results. The strips of gauze which have been placed in the grooves between the goître and the edges of the skin are intended to protect the mediastinum from infection by the fluids which exude abundantly at first from the exposed surface of the gland. These strips may be removed on the fourth day and need not be

replaced. The skin is then allowed to unite with the goître, and gradually re-covers it. Great care must be taken to keep the whole of the exposed surface aseptic during the process of cicatrization. According to Berard, whose book, *Thérapeutique chirurgicale du goître*, contains an excellent account of the operation, 'cutaneous cicatrization is complete, on the average, by the end of six weeks or two months.'

During the first few days after the operation there is a copious exudation of serous fluid from the exposed surface of the gland. This exudation comes partly from torn lymphatics, partly from the turgid veins compressed by the edges of the cutaneous wound, and consists also, in part no doubt, of the colloid secretion of the gland itself.

After a day or two the veins on the surface of the tumour, which are at first swollen and prominent, become thrombosed. They then gradually become smaller, until at the end of about a week they appear only as small brownish cords. Elevation of temperature is almost always present during the first eight or ten days after exothyreopexy. This has been explained as 'thyreoid fever' due to absorption of secretion from the interior of the gland.

In the course of several weeks after the operation the exposed gland gradually shrinks and recedes behind the skin. The latter encroaches upon the surface of the tumour, which becomes covered with a decreasing area of granulations, and finally by a scar. With regard to the ultimate appearance of the cicatrix, Berard expresses himself as follows :—'What is usually found at the end of some months (after exothyropexy) is a decolorized disk, the dimensions of which vary from those of a two-franc piece (1 inch), very smooth and shiny or else bossy, and which is adherent to the deeper parts of the neck, fixing them to the skin. Sometimes the appearance is still more ugly ; the little cysts which form during the shrinking of the tumour become adherent to the skin and project externally like true grafts of thyreoid tissue, resembling grapes embedded in the skin.'

Berard gives an excellent photograph of a scar produced by an exothyreopexy. It is certainly much more ugly than the scar produced by any ordinary extirpation or enucleation operation.

Complications. With regard to serious hæmorrhage, Berard is of opinion that with ordinary care it may usually be avoided, except in the case of very vascular goîtres and of those which are very adherent to surrounding parts. He lays down a rule with regard to hæmorrhage due to wound of capsular veins, *viz.* that the lobe that bleeds should be immediately luxated externally. This tends to obviate dangerous bleeding into the cellular tissue of the neck. The hæmorrhage, moreover, tends to stop spontaneously after dislocation has been effected. If

bleeding still continues, it can more easily be arrested by pressure or ligature. If luxation of the lobe proves to be impossible, the bleeding must be arrested by leaving clamp forceps applied to the bleeding parts.

Painful dysphagia appears to be common during the first two or three days after the operation. In about one-third of the cases bronchitis appears to be troublesome.

Complications due to the mechanical disturbance and displacement of the trachea appear to be not uncommon, although as a rule after exothyreopexy the dyspnœa is relieved. In some cases of exothyreopexy not only has the dyspnœa not been relieved but it has been positively aggravated. This will readily be believed by those who have had practical experience of the injurious effect of traction upon the trachea in the course of an ordinary operation of extirpation. If the dyspnœa be aggravated by exothyreopexy it is recommended that the goître be replaced, the surgeon contenting himself with the benefit that may follow mere division of the tissues in front of it; or tracheotomy may become necessary. This is, however, always a very serious complication of any operation upon a goître, owing to the danger of setting up sepsis in the wounded cellular tissue of the neck.

In some cases in which exothyreopexy was found impracticable, owing to the impossibility of effecting the dislocation, the tumour has been merely laid bare by the operation. The wound has been packed with gauze. Shrinking of the goître may follow this simple operation just as it may after a simple division of the isthmus. The possibility, however, of serious increase in the amount of dyspnœa due to inflammatory swelling must be borne in mind. Infection of the wound is obviously a serious danger, and one which is not easy to avoid. It is in the later stages of the healing process, when antiseptic precautions tend to become relaxed, that infection is apt to be produced. It may be followed by sloughing of the exposed gland and extension of the inflammatory process to the deeper parts of the neck and chest.

Mortality. It is difficult to judge of the true mortality after this operation. Berard has collected sixty-five cases of exothyreopexy performed chiefly upon parenchymatous goître, but also upon several exophthalmic goîtres. In four of these cases death resulted from pneumonia, septic infection with hæmorrhage, and acute Graves's disease (two cases) respectively.

Among the sixty-one cases that recovered were cases in which sloughing occurred, in which tracheotomy became necessary, or in which other operations, such as extirpation or enucleation, were subsequently performed. Many of the cases appear to have benefited greatly by the operation; others seem to have been improved but little, if at all.

CHAPTER VI

OPERATIONS FOR REMOVAL OF A PORTION OF THE THYREOID GLAND

By far the most useful and important operations upon the thyreoid gland are those in which some considerable portion of the gland is actually removed. These operations divide themselves into two main groups:

1. *Extirpation.* Operations in which more or less of the thyreoid is removed together with its glandular capsule.

2. *Enucleation.* Operations in which one or more encapsuled tumours are removed from within the gland.

Each group contains several varieties.

EXTIRPATION

Indications. (i) *Parenchymatous goître,* that is, one in which the whole thyreoid gland is enlarged, all its vesicles being distended with colloid secretion. Small parenchymatous goîtres not causing dyspnœa should never be treated by operation.

Very large prominent parenchymatous goîtres in young subjects are occasionally suitable for removal by extirpation even when dyspnœa is not dangerous or serious, provided that the patient is willing to run a certain amount of risk in order to get rid of an unsightly deformity.

It is *dyspnœa,* however, and especially the more severe forms of this symptom, which usually demands operation. All parenchymatous goîtres which produce serious dyspnœa, and which do not yield to medical treatment after a fair trial, should be treated by operation and not be allowed to progress indefinitely until life is urgently threatened. The dyspnœa of a parenchymatous goître has nothing to do with irritation of recurrent laryngeal nerves. It is due to direct pressure upon the trachea and nothing but the removal of the pressure will cure it.

If the goître be situated well above the sternum and consequently free to expand externally, the danger of death from suffocation is much less than when the goître is situated low down, in or near the upper opening of the thorax. The lower down in the neck the goître the more serious are its pressure effects. The most dangerous of all goîtres are those which are situated partly or wholly within the thorax.

If should be borne in mind also that the soft trachea of a child or young adult is much more liable to sudden and fatal compression than is the rigid and more resisting trachea of an elderly person.

(ii) *Multiple encapsuled tumours.* Whether enucleation or extirpation should be performed in cases where a number of comparatively small tumours are present is often a difficult matter to decide. Multiple enucleation may lead to serious hæmorrhage which can be avoided to a large extent by an extirpation operation.

On the other hand, an extirpation which removes all the tumours may involve the unnecessary sacrifice of a large amount of functionally active gland tissue. Frequently it is best to do a partial extirpation of one lobe and to content oneself with the enucleation of one or more tumours from the opposite lobe.

(iii) Certain rare cases of *subacute inflammation, chronic suppuration,* and *sinuses* left after injection may demand extirpation.

(iv) The rare form of inflammation known by the somewhat cumbrous name of *primary canceriform chronic inflammation* of the thyreoid gland should be treated by extirpation, if the case be seen early enough. The infiltration of neighbouring important structures, however, which occurs in the more advanced stages, will often render a satisfactory removal of the disease impossible. The operator who embarks on one of these operations should know when to leave off, and not jeopardize the life of his patient by making too prolonged an attempt at removal.

(v) *Malignant disease.* The operative surgery of malignant disease of the thyreoid is very unsatisfactory, a complete cure being only very rarely recorded. This is mainly owing to the fact that cases of malignant disease of the thyreoid are seldom seen by the surgeon at a sufficiently early stage of the disease, at that stage alone at which it is possible to effect complete removal of the growth. Owing to the anatomical situation of the tumour, lying as it does in close proximity to important structures, it is usually impossible to effect that free removal of the tumour and neighbouring parts which alone gives satisfactory results in the treatment of malignant disease. In a very early stage, while the growth is still confined within the gland, such removal is possible. But at this stage certain diagnosis is wellnigh impossible. A hard lump which is steadily growing in an elderly patient, if it be not a cyst, is probably a malignant tumour. But such a lump causes little or no trouble or even discomfort. At this stage the diagnosis is usually not made. If made, it is often difficult to persuade the patient to submit to operation.

If the tumours be allowed to grow until the glandular capsule has been penetrated, then the diagnosis is easy enough, but the favourable

time for operation has passed away. An irregular bossy lump, pain in the side of the neck and head, paralysis of the recurrent or sympathetic nerve, dysphagia, perhaps even dyspnœa, make the diagnosis only too plain. But by this time, even though the tumour be movable and apparently removable, the operator will find only too often, when he cuts down upon it, that infiltration of the trachea, œsophagus, or carotid vessels makes his operation practically futile.

He may endeavour, by resecting carotid vessels, cutting away portions of the trachea, œsophagus, or what not, to eradicate the disease. He may succeed in getting the wound to heal and for a short time the patient may be benefited. But a speedy recurrence is almost inevitable.

The only operation that affords a chance of cure is extirpation,—extirpation of the whole of the affected lobe and as much of the opposite one as may seem necessary. Complete bilateral removal of the whole gland is never desirable. If the disease has progressed so far as to make such a proceeding seem necessary, it is certain that the trachea or other neighbouring extra-glandular structures have already become affected, and it is better either not to operate at all, or to be content with some such palliative operation as linear incision or tracheotomy.

(vi) *Exophthalmic goître.* In this disease the whole gland is uniformly enlarged, the amount of retained colloid is diminished, and there is a marked increase in the epithelial elements of the gland. A gland which is the seat of a pre-existing cyst or adenoma may become the seat of Graves's disease. This accounts for the cases of asymmetrical goître with the ordinary symptoms of Graves's disease. Such cases as these may, perhaps, occasionally be treated with advantage by enucleation. But for the common form of exophthalmic goître, if deemed suitable for removal by operation, extirpation of some kind should be the operation of choice.

It must be remembered that all operations for exophthalmic goître involve serious risk to life and should seldom be recommended.

In bad acute cases and in all cases where the heart has been enfeebled by prolonged rapidity of action, there is grave danger of death occurring during or very shortly after operation.

In less severe cases operation may be permissible if preceded by careful and prolonged medical treatment.

During the operation excessive manipulation of the gland should be avoided as much as possible. Great rapidity of pulse after the operation may be controlled to a certain extent by the free use of massive saline injections *per rectum*.

After recovery from the operation the patient usually feels much better for a time, and in some cases the improvement is permanent.

More often, however, the symptoms return after some months and the ultimate condition of the patient may be worse than before.

It should be remembered that many cases of ordinary goître have considerable rapidity of pulse and a good deal of tremulousness. Such cases are often classed among those of true Graves's disease. It is the brilliant results often obtained by operation in this class of case that are partly responsible for the lamentable results so often seen after operations for genuine Graves's disease.

Operation. *General remarks.* This operation is one that should not be undertaken lightly or by any one who is not thoroughly familiar with the details of aseptic surgery, and of the pathological anatomy of the thyreoid gland. It involves a deep wound at the root of the neck in cellular tissue, which is exceedingly liable to septic infection. The dissection must be carried out in the midst of, and in close proximity to, various large and important structures, wound of any one of which may mean grave danger to the patient's life. The vessels which will be encountered are likely to be greatly dilated and their walls are easily torn. Serious hæmorrhage, once started, may be very difficult to control.

At every stage of the operation the operator should know exactly what he is doing, and be able to see precisely what he is about to cut. He should also remember, when operating upon large goitres, that the anatomical structures of the neck do not always occupy their normal positions, but are likely to be displaced and distorted by the goitre.

Especially should he remember that the lower part of a goitre often extends down behind the clavicle or sternum into a region into which it is dangerous to enter without a due knowledge of the conditions he may expect to meet with. There are often special dangers connected with respiratory distress or cardiac failure which he must be prepared to avoid, or to deal with should they occur.

Position of the patient. The shoulders should be well raised and the head thrown back as far as is consistent with comfortable breathing. It is well to ascertain, before administration of the anæsthetic, how far the head can be extended without serious embarrassment of the respiration. The head should be held firmly by an assistant and rotatory movements avoided, lest sudden dyspnœa should supervene from kinking of the trachea. If serious dyspnœa be present the patient may have to be propped up in a sitting posture.

Anæsthetic. If dyspnœa be not extreme, and the services of a really reliable anæsthetist can be secured, there is no objection to the administration of a general anæsthetic. The greatest care, however, should always be exercised with regard to the anæsthetic, and anæsthesia should never be deep. Sudden embarrassment in respiration may occur at any stage

of the operation, even in apparently simple cases. When extreme dyspnœa is present, it is best to perform the operation under local anæsthesia, or at most under very light general anæsthesia (see Vol. I, p. 31).

The anæsthetic of choice in most cases should be chloroform. For, operations on exophthalmic goître, or in cases where the heart is already much weakened by long-continued respiratory distress, ether is to be preferred, administered by the open method. A combination of the two methods is often useful, the administration beginning with chloroform and passing on to ether, especially after the dislocation of the tumour has been effected.

If serious asphyxia occurs at the commencement of the operation, it may be necessary to proceed rapidly with the dislocation of the tumour, thus relieving the pressure upon the trachea. Tracheotomy should not be resorted to, if it can possibly be avoided, as it increases enormously the risk of the operation.

If the services of a really reliable anæsthetist cannot be obtained, it is often safer not to employ general anæsthesia at all, but to be content with local anæsthesia.

Indeed, some surgeons seem to recommend the latter as the routine proceeding for nearly all goître operations.

Local anæsthesia should be induced by Schleich's method, eucaine, or eucaine and adrenalin, being injected into the skin along the line of proposed incision, and also into the deeper tissues in certain places (see Vol. I, p. 37). In making the latter injections great care is necessary to avoid wound of veins and consequent infiltration of the tissues with blood. Such infiltration might render much more difficult the subsequent steps of the operation.

In the case of children and of nervous subjects who cannot be trusted to keep still, general anæsthesia is preferable.

Operation is occasionally demanded in cases of extreme dyspnœa with marked cyanosis. In such cases general anæsthesia is highly dangerous and local anæsthesia is greatly to be preferred.

Skin incision. Any one of three incisions may be employed:

(*a*) A curved transverse incision low down in the neck. This gives much the best result from the cosmetic point of view, as the scar is low down and can easily be hidden by the dress or by a necklace (see Fig. 23). On the other hand, it does not allow such free access to the upper poles of the gland unless the incision be very long and the ends curved markedly upwards. For prominent goîtres, for those low down in the neck, and for median tumours it answers very well.

(*b*) An oblique incision near the anterior border of the sterno-mastoid gives free access to a unilateral goître, however large. The incision

should be carried well down to the episternal notch, except in the case of small tumours of the upper pole.

(*c*) A curved transverse incision across the middle or upper part of the goître, combined with a vertical median incision down to the episternal notch (the Y incision). This gives plenty of room and is suitable for large goîtres, especially if bilateral, and for most cases in which the operation is expected to be unusually difficult.

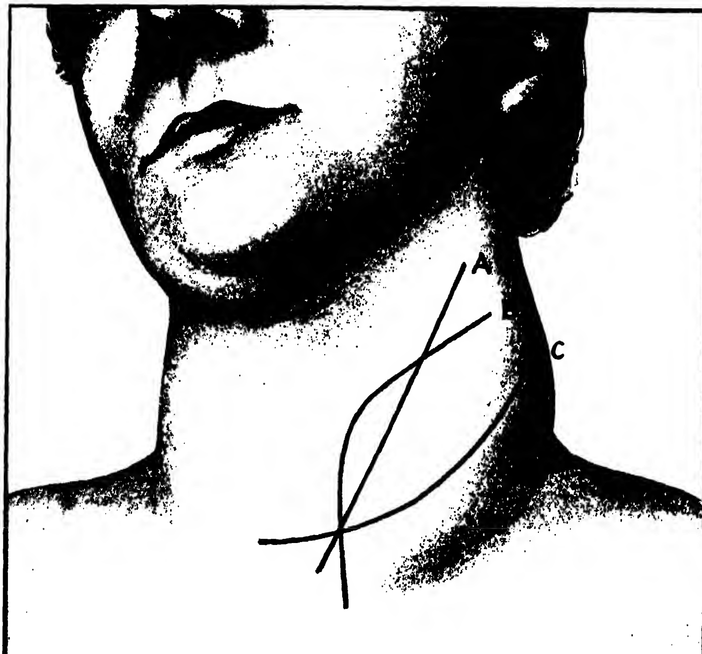


FIG. 12. SKIN INCISIONS SUITABLE FOR THE REMOVAL OF A LEFT-SIDED GOÎTRE. A and B give more room, but C gives a much better result as regards the subsequent scar.

The median vertical incision may be used for median and small tumours, but is not recommended, as it does not, as a rule, give sufficient access to the lateral parts of the gland.

We will assume that the transverse incision (A) is to be employed.

The first incision should be carried boldly through the skin and platysma. Both are dissected up in one flap until the upper part of the goître has been reached in the neighbourhood of the larynx. Various branches of the anterior jugular veins are now seen, and must be isolated and secured with pressure-forceps before being divided. A large vein running close to the sterno-mastoid will generally require special atten-

tion, as also a transverse communicating branch low down near the sternum.

Treatment of the infrahyoid muscles. The infrahyoid muscles must now be divided high up near the top of the larynx. A vertical incision is then made through the musculo-fascial layer nearly down to the sternum. The triangular flap of muscle and fascia on each

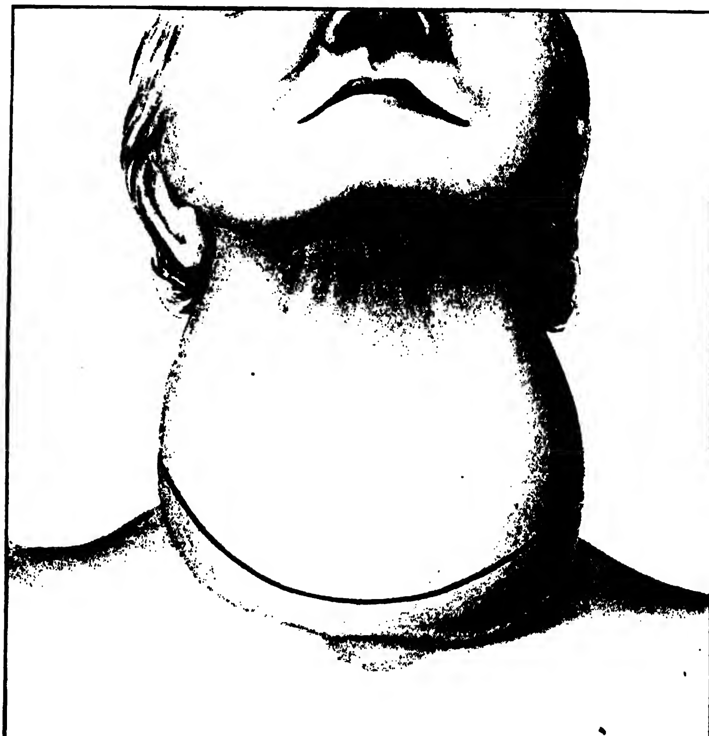


FIG. 13. EXTIRPATION OF THE RIGHT HALF OF A PARENCHYMATOUS GOÎTRE OF MODERATE SIZE. *First stage.* Incision through the skin and platysma.

side is then turned downwards and outwards, and the thyreoid gland exposed.

In dividing the infrahyoid muscular layer, the latter should be lifted up with forceps before it is cut, so as to avoid risk of injuring the underlying venous plexus. Blunt-pointed scissors are more useful than the knife at this stage.

In large parenchymatous goîtres and in goîtres of long standing, the infrahyoid muscles often lie in deep grooves in the gland. They must be carefully lifted out of these grooves before they are cut. All

layers of muscle and fascia lying in front of the gland must be carefully and freely divided so as to expose thoroughly the thyreoid gland with the network of veins lying upon and in it. Great care must be taken not to wound this plexus, the veins of which are often much distended. If pricked they bleed freely, and the hæmorrhage is difficult to control. It is essential that the operator at every stage of the operation should see exactly what he is doing. This cannot be done if blood is effused into the cellular tissue of the neck.

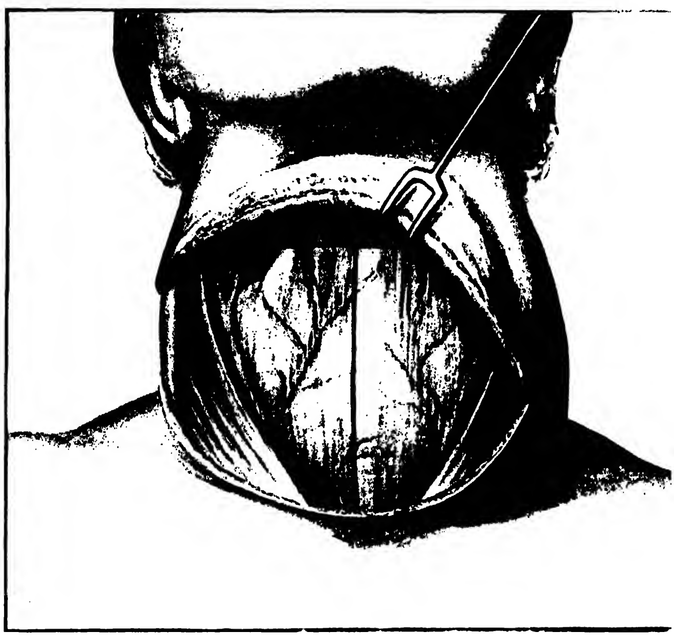


FIG. 14. EXTIRPATION OF THE RIGHT HALF OF A PARENCHYMATOUS GOÎTRE. *Second stage.* A flap of skin and platysma has been dissected upwards, exposing the sterno-mastoid muscles, the anterior jugular veins and their branches, and the infra-hyoid muscles. The latter will be lifted up with dissecting forceps and divided with scissors in the direction of the thick black lines.

Every bleeding point of the wound should be immediately secured with pressure-forceps. But the veins of the thyreoid plexus itself should not be allowed to bleed, since the application of forceps is very apt to tear them and to cause further and perhaps serious hæmorrhage.

Up to this point the operation of extirpation is identical with that of enucleation, presently to be described. But from this point onwards the two operations differ.

In performing extirpation the operator keeps outside the gland and seeks to tie all main vessels before he interferes with the gland itself.

The enucleator penetrates the gland and takes out the tumour from within it.

Luxation of the tumour. If the goître be fairly movable, an attempt should now be made to dislocate one or both lobes forwards out of the wound. The forefinger should be inserted very gently and carefully between the gland and the internal jugular vein, which lies close to its outer border. The goître is then pushed forward and brought out of the

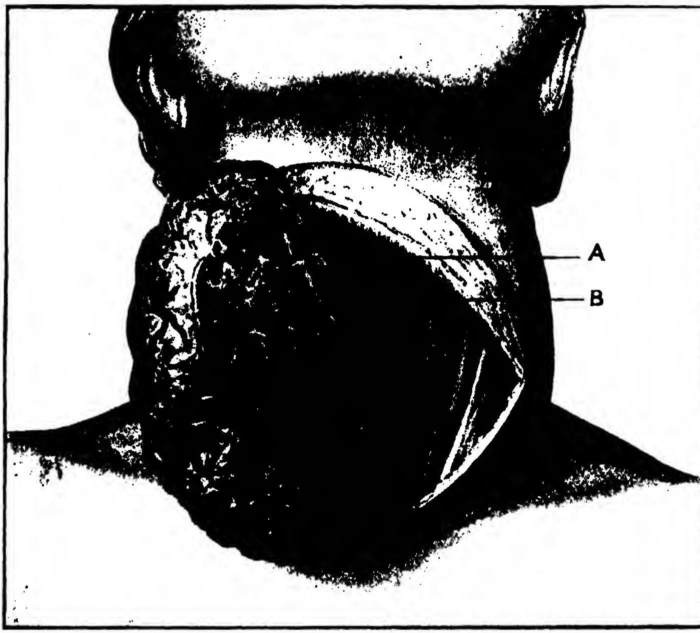


FIG. 15. EXTIRPATION OF THE RIGHT HALF OF A PARENCHYMATOUS GOÎTRE. *Third stage.* The infrahyoid muscles, A, have been divided and their lower ends have retracted out of sight. The right lobe of the goître has been herniated out of the wound either before or after ligature and division of the superior thyreoid artery and vein. Large middle and inferior thyreoid veins are seen ramifying on the surface of the goître, covered only by a very thin and delicate layer of connective tissue. B, The edge of the divided platysma.

wound. If the middle thyreoid veins are much in the way they may have to be clamped and tied before the finger is thus inserted. The greatest possible care must be taken not to tear them and thus cause hæmorrhage into the cellular tissue. Care must also be taken at this stage not to pinch the trachea, possibly already much flattened and very liable to become completely occluded if dragged upon or unduly compressed.

Ligature of vessels. The principal vessels which now require ligature are the superior thyreoid artery and vein near the apex of the lobe, the

large inferior thyreoid veins at the lower pole (often very difficult and troublesome to get at), and the middle thyreoid veins, if these have not already been tied. Either pressure-forceps or double ligatures must be carefully and securely applied to all these before they are divided. If a divided and unsecured inferior thyreoid vein slips back into the mediastinum it may be very difficult to secure it again.

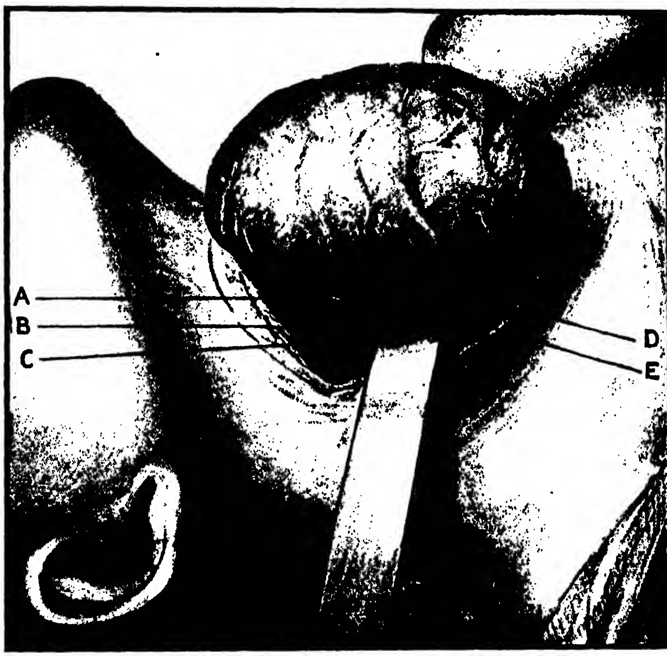


FIG. 16. EXTIRPATION OF THE RIGHT HALF OF A PARENCHYMATOUS GOÎTRE. *Fourth stage.* The isolated lobe has been turned over towards the middle line. The inferior thyreoid artery and its accompanying veins are seen at the posterior and inner border of the lobe. A, Œsophagus; B, Prevertebral muscles; C, Carotid sheath; D, Recurrent laryngeal nerve; E, Main trunk of the inferior thyreoid artery with its accompanying veins.

The veins along the upper and lower borders of the isthmus may be secured temporarily with clamps. If the isthmus be small, it may be compressed with a long-bladed pair of pressure-forceps.

The goître should now, if possible, be turned over towards the middle line while the inferior thyreoid artery is dealt with. If the isthmus be very thick or the goître very firm and fixed, it may be impossible to turn the latter inwards. In this case the isthmus should be divided and the goître turned outwards, the inferior thyreoid arterial branches being secured

as the gland is being separated from the trachea. In most cases, however, it is possible to turn the goître over sufficiently to obtain access to the artery from the outer side.

The main trunk of the artery may be secured before it divides. But usually it is better to clamp and tie separately the branches of this vessel after it has crossed the recurrent laryngeal nerve, and not too near to this important structure. The nerve generally passes over the artery, but sometimes behind it, and often between its diverging branches. The position of the nerve should be known to the operator and avoided by him. It is best not to expose and hook aside the nerve (as is recommended by some) because it is liable thereby to become involved in the scar and to suffer temporary or even permanent paralysis.

Division of the isthmus and removal of the tumour. All the principal vessels having now been secured, the isthmus may be divided with scissors or knife, and the connexions of the gland with the trachea on its inner side are then cut through. At this stage care is sometimes necessary to avoid wounding the trachea or larynx. Hard, calcified masses in the gland sometimes simulate the trachea rather closely. A softened and flattened trachea in a young subject may not be readily recognized as such by those not familiar with this class of operation.

After removal of the tumour a few vessels on the side of the pharynx or elsewhere may require ligature. The various vessels that have been clamped at the earlier stages of the operation must now be tied.

The greatest attention must be paid to hæmostasis. Every bleeding point must be thoroughly secured before the wound is closed. Recurrent venous hæmorrhage is (after sepsis) the one serious danger of a large thyreoid operation. After all the bleeding points have been apparently secured, the efficiency of the hæmostasis should be tested, *before the wound is closed,* by making the patient strain. The anæsthetist, who should be prepared for this, has allowed the patient at this point to come round so much that tickling the interior of the pharynx with his finger or a pair of forceps readily induces straining or coughing. If any vein is then seen to bleed (and sometimes even a large one may do so) it can easily be tied. If bleeding is going to occur when the patient strains, it is better that it should do so now, while the wound is still open, rather than an hour or two later, when the patient is back in bed, and may be straining and vomiting as the result of the anæsthetic.

Closure of the wound. All hæmorrhage having been completely arrested, the wound is now closed. First, the divided infrahyoid muscles must be replaced and the cut edges united with fine sutures. If this be not done a most unsightly hollow is afterwards found to have been left in the neck.

A drainage tube having been inserted into the wound and brought out at the episternal notch, the platysma is carefully united by buried sutures, and finally the thin incision is accurately closed by fine continuous sutures or by Michel's clips.

Very fine silk (No. 0 or at most No. 1) should be used for all ligatures. If a thicker ligature seems necessary for a large artery or vein, it is best to make use of the same fine silk, doubled or even trebled. The silk

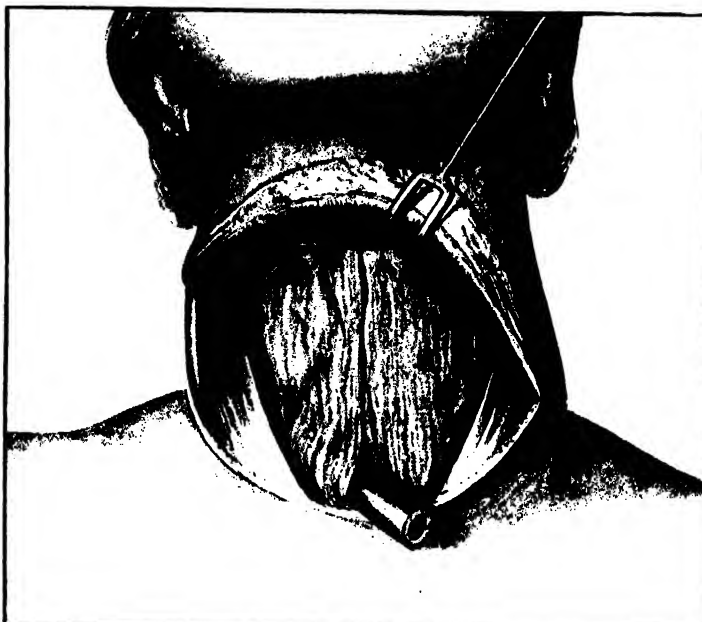


FIG. 17. EXTIRPATION OF THE RIGHT HALF OF A PARENCHYMATOUS GOÎTRE. *Fifth stage.* The tumour has been removed and the infrahyoid muscles have been replaced and sutured. A drainage tube has been placed at the lowest part of the wound.

should of course be boiled immediately before the operation. Throughout the operation the wound should be kept covered up as much as possible by layers of sterile gauze (see Fig. 18). Only that part of the wound at which the operator is actually working should be left exposed at any one time. The operator and his assistants should of course wear rubber gloves.

After the application of the dressing, the head, neck, and upper part of the thorax should be enveloped in bandages, care being taken not to apply much pressure to the neck itself or to constrict the thorax in such a way as to hinder respiration.

For the after-treatment of the case see p. 87.

MODIFICATIONS OF EXTIRPATION

Resection. This is a mere variety of partial extirpation. After the lobe of the gland has been isolated everywhere except on the inner side, the isthmus is divided. The attached portion of the gland is then cut through in such a manner that a portion of the lobe, generally about as large as a walnut, next to the trachea and laryngeal nerve, is left behind. Any vessels requiring ligature are clamped either before or after their division. Most of them will be found near the surface just under the capsule.

The advantages of this operation over extirpation of the whole lobe are (i) that some of the gland is left to carry on the function of the organ on the side operated on, (ii) that the recurrent laryngeal nerve is less liable to exposure and damage, and (iii) that no unsightly hollow is left in the region from which the goître has been removed.

This operation and the next are particularly suitable for cases of bad parenchymatous goître where it is necessary to operate upon both lobes simultaneously.

Resection-extirpation. This operation closely resembles the last, but differs from it in that the isthmus is not divided. The lobe is isolated as before, and a section is then made through the gland from before backwards. This section may be vertical or oblique, or even transverse, according to the situation of the portion of the lobe which it is desired to remove.

Amputation is a term applied to the removal of a goître by simply cutting across its neck. It is an operation of very limited applicability. It may be employed occasionally in cases of prominent or pendulous goîtres with a relatively narrow pedicle.

INTRAGLANDULAR ENUCLEATION

Indications. This operation is suitable only for encapsuled tumours (cystic or solid), and depends for its feasibility on the fact that such tumours generally have a sharply defined surface easily separable from the gland in which they are imbedded.

The diagnosis is generally made from the shape of the swelling. Encapsuled tumours are round or oval, while parenchymatous swellings preserve the natural pyriform shape of the gland.

Practically, all strictly unilateral swellings of the thyreoid (with the exception of inflammatory swellings and malignant tumours) are encapsuled tumours and therefore capable of being enucleated.

Enucleation should never be attempted in any case of parenchymatous goître. As in the case of extirpation of parenchymatous goître, dyspnœa is the main symptom which calls for the operation of enucleation. As the operation is, however, usually much less serious than that of extirpation, it is frequently permissible to perform it merely on the grounds of deformity or discomfort, especially if the latter be increasing. For small tumours simple enucleation is the best operation; for large ones, the modification of resection-enucleation (see p. 86) is preferable.

Operation. The earlier stages of enucleation down to the exposure of the thyreoid gland are exactly the same as those of extirpation (see p. 71).

After the thyreoid has been exposed and the operator by inspection and palpation of the swelling has confirmed his diagnosis that an enucleable tumour is present, he freely and boldly incises the gland down to the surface of the tumour itself.

The latter is then shelled out by means of blunt instruments. For this purpose he may employ either Kocher's special enucleator or his finger, or, better still, a closed pair of blunt-pointed dissecting forceps. At this stage much assistance may often be derived from pushing the tumour forwards by means of a finger placed behind it on the skin of the posterior triangle. Care should be taken both by the operator and by the anaesthetist to watch the patient's breathing during the actual enucleation, lest dangerous respiratory distress be produced by pressure upon the trachea. This is particularly likely to occur during the enucleation of tumours which are deeply seated behind the sternum or clavicle. The whole of the anterior surface of the tumour should be thoroughly cleared from the gland tissue before enucleation of the posterior part is attempted. Care must be taken to avoid pressing the tumour against the trachea, especially if this be already much flattened and narrowed, as it often is.

Difficulties and dangers. The two principal difficulties of the operation are—

(i) Recognition of the surface of the tumour itself.

(ii) Hæmorrhage.

(i) *Recognition of the surface of the tumour.* The tumour may lie at some little depth below the surface of the gland. On the other hand, if at all large, it has generally caused so much atrophy of the overlying gland tissue, that it appears to be on the surface and to be covered only by the connective-tissue capsule of the gland. It is important to bear in mind that a thyreoid tumour, however superficial it may appear to be, is *always* covered by a layer of true thyreoid tissue. Through this

layer, whether thick or thin, the operator must penetrate before the shelling-out process is commenced, or he will get into trouble with hæmorrhage and perhaps damage important surrounding structures. The surface of the tumour is generally easily recognized by its colour, which is very different from the maroon red colour of the enclosing gland tissue. The colour of the tumour varies considerably. It is often of a bluish tint, especially if there be extravasated blood within the tumour. Old thick-walled cysts and adenomata, such as that depicted in Figs. 20 and 21, are often of a dull buff yellow colour. The operator must avoid, on the one hand, beginning the enucleation before the actual tumour has been reached. On the other hand, he must take care not to cut into the tumour and thus miss the dividing layer between tumour and gland in which alone enucleation can be properly performed.

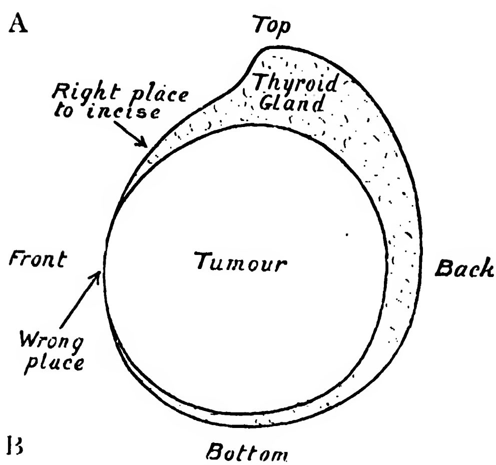


Fig. 18. Vertical Section through an Encapsuled Adenoma and its Containing Lobe. To show where enucleation should be begun, *viz.* where the enclosing gland tissue is fairly thick and easily distinguishable from the tumour. At the most prominent part of the tumour the enclosing layer of gland tissue is often exceedingly thin and firmly adherent to the surface of the tumour itself. (*Diagrammatic.*)

When enucleating the posterior part of the tumour, it is very easy to leave the surface of the tumour and to penetrate the glandular layer.

If the tumour be cystic or very soft and friable, it often bursts and collapses during the enucleation. In such a case it is best to lay hold of the tumour with several pairs of pressure-forceps and to draw it forwards. The glandular sheath may then be peeled off by means of ordinary dissecting forceps held in the other hand. Any vessel seen during this part of the operation should be at once seized with clip-forceps. If the glandular layer over the anterior surface of the tumour be very thin or adherent, as it often is, there may be considerable difficulty in finding the proper layer in which to begin the enucleation. The operator is apt to penetrate into the interior of the tumour and to lose his way there. It is frequently better to begin the enucleation, not at the most prominent part of the tumour where the gland tissue is thin and difficult to separate, but somewhere else nearer the periphery of the

tumour where it is covered with a thicker layer of easily distinguishable gland.

Thus in the diagram (see Fig. 18) the proper place to incise the gland would be at A and not at B.

(ii) *Hæmorrhage.* The amount of hæmorrhage that takes place during

FIG. 19. RESECTION-ENUCLEATION OF A LEFT-SIDED ENCAPSULED TUMOUR (THICK-WALLED CYSTIC ADENOMA). The left lobe with its tumour has been dislocated forwards out of the wound. The whole of the surrounding skin area, together with all parts of the wound at which the operator is not actually working at the time, is kept covered up with thin layers of moist sterile gauze to ensure asepticity of the wound. In the other illustrations the gauze has been omitted for the sake of clearness.

the enucleation varies much. If the tumour be small the hæmorrhage is but trivial and most of it can be arrested by packing the cavity with gauze. The packing is left *in situ* for a few minutes while the operator proceeds to tie the superficial vessels which were clamped at an early stage of the operation. When the gauze is removed the few points that still bleed can easily be seen and tied.

If the tumour be at all large the amount of blood that is lost during the few moments occupied by the enucleation and afterwards may be considerable and even dangerous. In these cases it is not safe to trust to gauze packing. The walls of the cavity in which the tumour lay should be seized with forceps and drawn forwards. By means of forceps placed

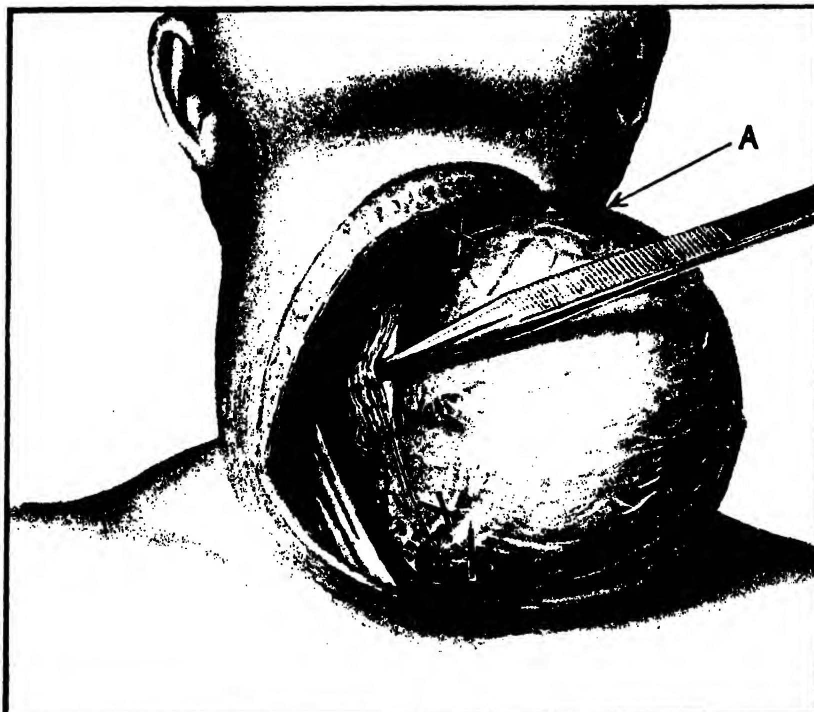


FIG. 20. RESECTION-ENUCLEATION OF A LEFT-SIDED ENCAPSULED TUMOUR (THICK-WALLED CYSTIC ADENOMA). The left lobe of the gland, with the tumour, has been dislocated out of the wound. Pressure-forceps or ligatures (omitted for the sake of clearness) have been placed upon various large vessels, marked by crosses. An incision has been made through these vessels and the glandular layer covering the tumour. Enucleation of the tumour itself has been begun. Care must be taken to isolate each large vessel before it is clamped or tied. A marks the position of the superior thyreoid artery and vein, which have already been tied.

at the bottom of the cavity, the latter can be completely everted and the bleeding points seen and secured. The amount of hæmorrhage may be lessened by ligature of the superior thyreoid artery before incision of the gland. Or the whole lobe may be dislocated forward and the inferior thyreoid artery tied (after ligature of the middle thyreoid veins) before the glandular tissue is incised.

But in all cases of large tumour where serious hæmorrhage is to be feared it is best not to do simple enucleation, but to substitute the far preferable operation of resection-enucleation (*vide infra*).

After removal of the tumour or tumours and the complete arrest of all hæmorrhage, the wound in the gland itself may be sewn up by two

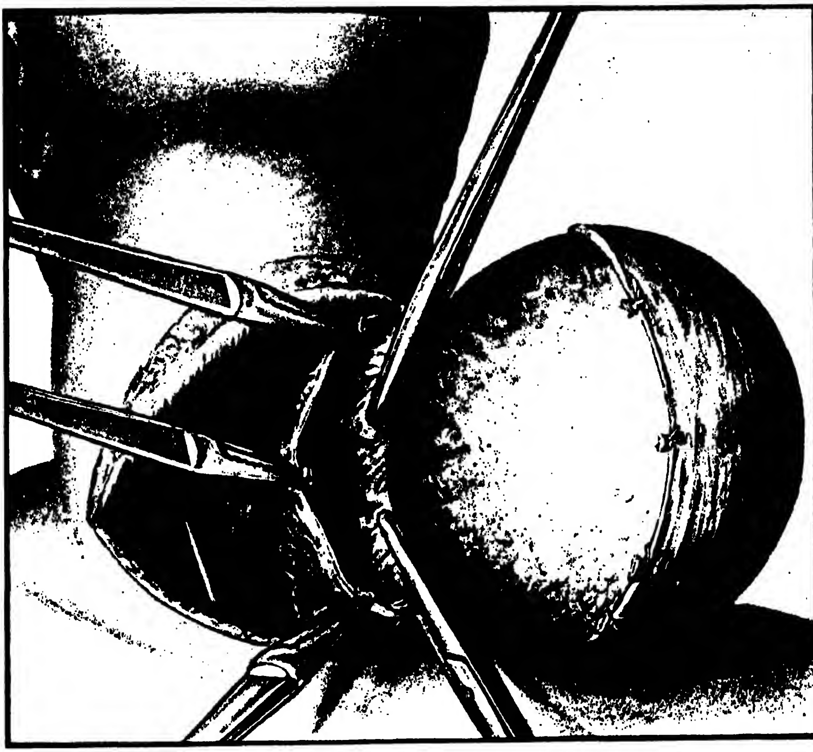


FIG. 21. RESECTION-ENUCLEATION. A later stage of the same operation. The tumour, rotated outwards, has been enucleated on its inner and posterior surface until a line has been reached which is well outside the position of the recurrent laryngeal nerve and internal jugular vein. Clamps have then been applied, above and below, to the posterior part of the glandular capsule, which is then cut through with scissors outside the line of those clamps. The whole tumour, together with the thin glandular capsule, still adherent on its anterior and outer aspects, has then been removed.

or three purse-string sutures of catgut or very fine silk passed transversely across the walls of the cavity, care being taken not to transfix any extra-glandular structure. This step obliterates the cavity in which blood or colloid might otherwise collect. The subsequent closure of the wound is the same as after extirpation.

MODIFICATIONS OF ENUCLEATION

By far the most important of these is

Resection-enucleation, which, indeed, should be the operation of choice for all large encapsuled tumours.

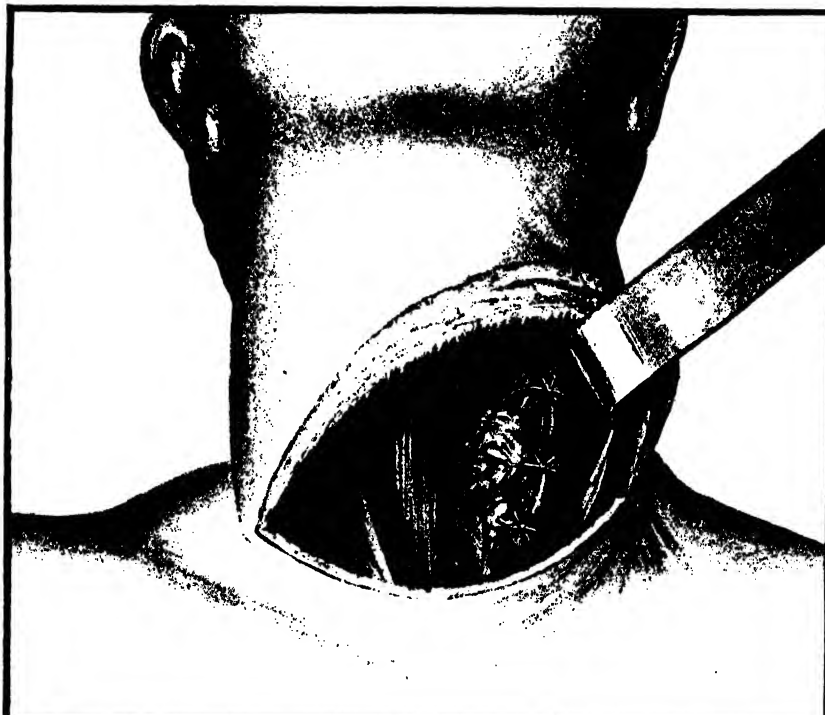


Fig. 22. Resection-enucleation. The tumour having been removed and all bleeding points thoroughly secured, the cut edges of the thyreoid gland are brought together and united by a few fine sutures.

It differs from simple enucleation in that a considerable portion of enclosing, but thinned and functionally useless, glandular capsule is removed with the tumour. The enucleation area from which hæmorrhage can take place is thus greatly reduced in size. After exposure and, if possible, luxation of the tumour, a vertical incision is made on the inner side through the glandular capsule. Enucleation is then carried out on the inner and posterior aspect of the tumour until a point has been reached posteriorly which is well outside the region of the recurrent nerve. Care being taken to avoid wounding the internal jugular vein,

the glandular capsule is then again incised vertically and the tumour removed together with the unseparated portion of glandular capsule. The principal vessels should be seized as the enucleation proceeds. Many of them may with advantage be clamped even before the capsule is incised. Any bleeding points on the cut surface of the gland are tied. The wounded surface is then still further diminished in size by uniting its anterior and posterior surface with a few sutures, which may with advantage be passed in a purse-string manner as above described under enucleation. The lines of incision through the capsule may be varied according to the situation of the tumour and consequently of the portion of gland which it is desired to preserve.

Évidement is an operation of but little importance. It consists in cutting the tumour across and scraping out its contents from the inside. It is chiefly applicable to soft solid tumours with very thin walls which may be difficult to enucleate satisfactorily. It is occasionally required for a fixed tumour which cannot be lifted out of the glandular bed in which it lies. If the tumour be solid and of large size the resulting hæmorrhage may be extremely serious.

AFTER-TREATMENT OF EXTIRPATION AND ENUCLEATION

When the patient returns to bed she should be propped up at an angle of 45° with pillows or a bed-rest.

In this position the patient is usually much more comfortable than when lying on the back. The position also favours drainage of colloid and blood-stained serum, a very important matter if primary union is to be obtained, as it should be.

If the patient be old or feeble or suffering much from shock, she may be allowed to lie on her side for a few hours.

If the operation has been unilateral she should lie on the side opposite to that of the operation. If bilateral, she should lie alternately on the two sides, the position being changed every few hours. In some cases of retrosternal and intrathoracic goître where drainage is otherwise difficult, the patient should occasionally be rolled over on to her face for a few minutes once or twice a day, in order to secure thorough drainage of the cavity.

Occasionally in bad cases of retrosternal goître where a large cavity has been left, the sides of which cannot be approximated, it may be necessary to pack with gauze for several days. But as a rule even large cavities close up very quickly, so that prolonged drainage is very seldom necessary.

In the great majority of cases, if the operation has been properly

performed, the drainage tube should be removed on the day after that of the operation, and not replaced.

Thirst and restlessness after the operation are best treated by massive rectal infusions of normal saline solution at the body temperature. The fluid should be injected very slowly through a small soft rubber catheter attached by means of a rubber tube to a jug raised only a few inches above the level of the rectum. The fluid then trickles slowly into the rectum and is absorbed as quickly as it enters. If given too quickly, or if too hot or too cold, it will not be retained. If the patient does not vomit, fluids may be given freely by the mouth. In the first twenty-four hours little or no food of any kind should be given. Indeed, it is best in most cases to withhold food until the patient expresses a desire for it.

A B

FIG. 23. THE SCAR AFTER OPERATIONS UPON THE THYREOID GLAND. A shows the transverse scar of a bilateral resection-extirpation operation. B shows how the transverse scar in this position can be completely hidden by a necklace. (*From a photograph.*)

On the other hand, after most thyreoid operations what the patient does require is fluid, and fluid in considerable quantities. After the sickness has passed off she should be encouraged to drink hot water, weak tea, barley-water, or similar drinks.

In the writer's practice, the patient is allowed to get out of bed for a short time on the second or third day in all but the most severe cases. The stitches are removed on the fourth day. By this time the wound should be soundly healed.

If recurrent hæmorrhage takes place within a few hours of the operation, as may be the case if the vessels have been incompletely ligatured, the wound should be opened up freely, the clots turned out, and an attempt made to secure the bleeding vessels.

This is often a very difficult task and may prove to be impossible. If the bleeding be found to come from a number of very small vessels rather than from a single large one, it is best to pack the wound with gauze and to treat it in a more or less open manner.

Post-operative hæmorrhage is, however, always a serious complication, and is best treated by ensuring that it shall not occur, that is, by

exercising the most scrupulous care in arresting all hæmorrhage before the wound is closed.

The temperature and pulse should be taken every four hours after the operation. If neither rises above 100 and the patient's general condition is good no anxiety need be felt as to the progress of the case. If either of them rises much above this level and remains so for more than a few hours the operator should be ready to open up the wound and to re-establish efficient drainage. If serious symptoms of sepsis supervene, no time should be lost in opening up the whole wound and packing with dry sterilized gauze. Rapidity of pulse, if not due to sepsis, is best treated by massive rectal saline infusions. Some amount of pain in deglutition is not uncommon in the first day or two. Should it last longer than this it generally indicates inflammatory trouble in the wound. A mild aperient should be given within forty-eight hours of the operation, or sooner if any serious elevation of temperature takes place.

CHAPTER VII

REMOVAL OF THYREO-GLOSSAL AND BRANCHIAL CYSTS AND FISTULÆ

THYREO-GLOSSAL CYSTS

THESE are formed in connexion with the tract of thyreoid tissue that extends from the isthmus of the thyreoid gland upwards to the foramen caecum at the base of the tongue.

The lower part of this tract often persists as the pyramid or middle lobe of the thyreoid gland.

Cysts or adenomata may form in it just as they do in any other part of the thyreoid gland. Such tumours lie in front of the larynx, usually slightly to one or other side of the middle line.

They can easily be removed through a median or a transverse incision. They may be enucleated, but it is generally best to remove the whole of the pyramid, after isolating and tying its upper and lower extremities.

That portion of the tract which extends from the apex of the pyramid to the foramen caecum usually becomes obliterated at an early period, but may persist as a slender fibrous cord or a minute canal.

Cysts forming in this originally tubular structure are not uncommon. The proper treatment for such a cyst is to dissect it out, remembering that a process runs upwards behind the hyoid towards the base of the tongue. If this upward extension be not removed the wound will not heal or the cyst will be reproduced. Occasionally it may even be necessary to divide the hyoid bone in the middle line with bone forceps, to obtain access to the uppermost portion. A vertical incision is often employed for the removal of cysts, but a transverse incision gives a better cosmetic result and adds but little to the difficulty of the operation. Rarely the uppermost part of the thyreo-glossal duct above the hyoid becomes dilated and forms a cyst at the base of the tongue.

Such cysts occasionally form tumours of considerable size within the mouth and may interfere seriously with swallowing and speaking. They may be removed without much difficulty from within the mouth by enucleation. The tongue must be drawn well forwards and ordinary care must be exercised to prevent blood running into the larynx.

REMOVAL OF BRANCHIAL CYSTS AND FISTULÆ

These are due to the persistence of more or less of the three posterior branchial clefts on either side of the neck.

If there be an external opening it will be found at the anterior border of the sterno-mastoid muscle, either just behind the angle of the jaw, opposite the thyreo-hyoid space, or a little above the inner end of the clavicle, according to the cleft affected.

If there be no external opening the unclosed portion of the persistent cleft may become dilated into a cyst occupying any of the above situations. A narrow cord-like process can often be seen or felt extending upwards from the cyst towards the pharynx.

In dissecting out such cysts, this upwards extension must always be removed. This involves a deep and careful dissection upwards between the internal and external carotid vessels as far as the pharynx. If the whole of this tubular prolongation be not removed, the cyst is reproduced.

SECTION II

OPERATIONS UPON THE BILE PASSAGES AND THE PANCREAS

BY

A. W. MAYO ROBSON, D.Sc., F.R.C.S. (Eng.)
Consulting Surgeon, Leeds General Infirmary

CHAPTER I

THE SURGICAL ANATOMY OF THE BILE PASSAGES: GENERAL REMARKS: OPERATIONS FOR INJURY TO THE BILE DUCTS

ANATOMICAL CONSIDERATIONS

The gall-bladder. The gall-bladder is situated on the inferior surface of the right lobe of the liver in a large but shallow depression termed the cystic fossa, the peritoneum covering the under surface of the liver being reflected on to and covering the unattached fundus and inferior surface.

It is usually pear-shaped, the large extremity lying anterior to and below the neck, where it merges in the cystic duct. It varies considerably in size according to the volume of its contents. In a state of moderate distension it holds from 50 to 60 cubic centimetres of bile. Its walls are very elastic, and it is possible to introduce under pressure from 200 to 250 cubic centimetres of water without producing rupture. If the distension be continued, rupture occurs close to the neck of the organ.

The rounded *fundus*, when distended, projects beyond the free border of the liver, the margin of which presents a more or less distinct notch—the cystic notch—and comes into contact with the anterior abdominal wall close to the margin of the ninth or tenth costal cartilage immediately below the point where the outer edge of the rectus abdominis muscle crosses the costal margin.

The *body* of the gall-bladder presents two aspects, a superior and an inferior. The superior surface is in contact with the cystic fossa, to which it is united by some loose connective tissue and by vessels passing between the gall-bladder and the liver.

The lower surface is covered by peritoneum in its whole extent. It lies in contact with the second part of the duodenum and with the transverse colon. Its relations, however, vary considerably according to the state of distension of the organ. It may be pushed upwards and lie in contact with the first part of the duodenum, with the pylorus, or with the anterior surface of the stomach; or it may be displaced downwards and lie in contact with the ascending colon or the anterior surface

of the right kidney. Occasionally a fold of peritoneum connects the body of the gall-bladder to the anterior aspect of the transverse colon.

The *neck* of the gall-bladder is the narrowest part of the organ. It is bent into the shape of the letter S, and maintained in this position by loose connective tissue and by the peritoneum which covers it. Internally, two inflexions give rise to the formation of two valves of mucous membrane, the lower of which separates the gall-bladder from the cystic duct.

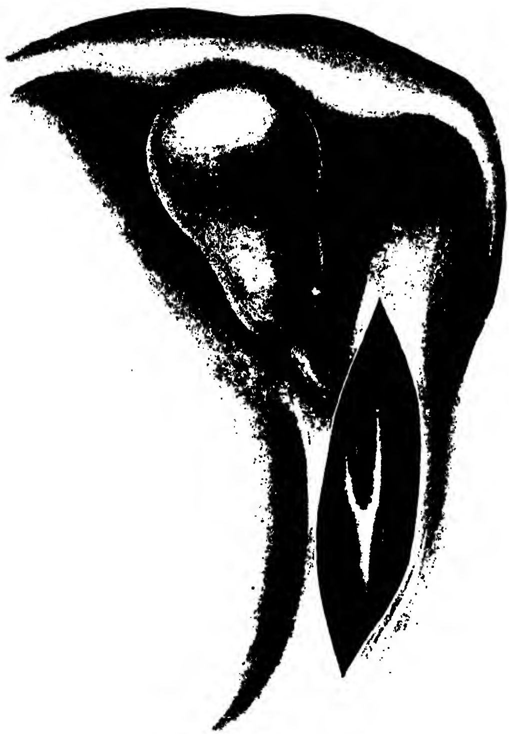


FIG. 24. THE GALL-BLADDER AND BILE DUCTS.

The *serous covering* of the gall-bladder is continuous with the peritoneum covering the under surface of the liver. It covers all that portion of the gall-bladder which is not in contact with the cystic fossa. The fundus of the gall-bladder is completely covered by peritoneum, and its upper surface, unlike the body of the organ, is not in direct contact with the surface of the liver. It is separated by a double serous fold, the angle of which is formed by the reflection of the peritoneum from the margin of the liver on to the fundus of the gall-bladder.

Occasionally the gall-bladder is completely invested by peritoneum, there being on the upper aspect a distinct mesentery, which allows more or less free movement.

A much more common condition found on the operating table is the presence of a mesentery, not reaching the fundus, but extending to the lower third or half of the gall-bladder.

When moderately distended the gall-bladder is usually to be felt in the direction of a line drawn from the ninth or tenth costal cartilage and passing somewhat to the right of the umbilicus; but this position may be altered from an unusual size of the left lobe, or other structural

variations of the liver, so that it may even project into the right lumbar region. On the other hand, especially where there have been repeated attacks of gall-stone colic, extending over a long period, it is more usual to find the gall-bladder smaller than normal, and occupying a position just in front of the transverse fissure of the liver. So far may this contraction go that there may be almost complete obliteration of the sac, a condition which, when extreme, may be described as cholecystitis obliterans. In these cases there is not infrequently increased difficulty in recognizing the true relation of the parts, from the adhesions of some of the surrounding organs by more or less intimate bonds to the gall-bladder and liver, so as completely to hide the gall-bladder from view when the peritoneal cavity is opened.

With cirrhosis of the liver the gall-bladder is carried up well under the ribs, while if the liver is enlarged from any cause or displaced downwards by emphysema of the lungs the gall-bladder will be pushed to a lower level. I have seen it in the cæcal region and even in the pelvis.

The blood-supply of the gall-bladder is derived from the cystic artery, a branch of the right division of the hepatic artery. This vessel runs by the side of the cystic duct to the neck of the gall-bladder, and there divides into two branches, an internal and an external, which run on either side of the viscus to the fundus. In addition, the gall-bladder receives some very fine branches which come directly from the liver.

The cystic veins enter the right branch of the portal vein. The nerve-supply is derived from the cœliac plexus of the sympathetic.

The cystic duct extends from the gall-bladder to the termination of the hepatic duct, with which it unites to form the common bile duct. It is from 33 to 45 millimetres in length, and has a diameter of from 3 to 4 millimetres, being narrowest at the point where it joins the hepatic duct. It resembles in structure the wall of the gall-bladder, and presents a convoluted appearance, owing to the infolding of the mucous membrane in the form of valves in the interior (see Fig. 25).

The hepatic duct originates at the right extremity of the transverse fissure of the liver by the junction of the two or three terminal biliary ducts. Thence it runs downwards and a little from right to left, to terminate in the common bile duct. The diameter of the duct measures from 4 to 5 millimetres. Its length is usually at least 3 centimetres, but it varies considerably in different subjects. These variations depend on one or other of the two following conditions: the uncertain point of junction of the terminal biliary ducts, and the high or low union of the cystic duct.

Very rarely the terminal biliary ducts, two or three in number, unite

directly with the cystic duct to form the common bile duct. In such a case the hepatic duct does not exist. In its whole course the hepatic duct is situated between the two layers of the gastro-hepatic omentum. Above, at its origin, it crosses perpendicularly on their anterior aspect the right branches of the hepatic artery and the portal vein. Below, it runs on the antero-external aspect of the portal vein, which position it maintains to its termination. It is in intimate relationship with the lymphatic glands at the hilum of the liver, and also with the nerves running to the liver.

FIG. 25. DIAGRAM TO SHOW THE CONVOLUTED APPEARANCE OF THE CYSTIC DUCT. (*Modified from Testut.*)

The common bile duct results from the junction of the cystic duct with the hepatic duct; it receives the bile from these two canals, and transmits it into the second portion of the duodenum. It runs in a direction continuous with that of the hepatic duct from above downwards a little from right to left, running behind the first part of the duodenum to the upper border of the head of the pancreas. Then it turns a little to the right and forwards within the pancreas to the postero-internal aspect of the second portion of the duodenum. It traverses the wall of the intestine, into which it opens.

It may be divided into four parts:

(*a*) The supraduodenal.
(*b*) The retroduodenal.
(*c*) The pancreatic.
(*d*) The intraparietal.

The canal in its entirety describes a curve with the concavity to the right. It varies in length from 6 to 8 centimetres, while its diameter is a little greater than that of the hepatic duct. According to Quénu, an average taken from twenty subjects gives the circumference of the duct as 13 millimetres. The common duct is very extensile, as are also the other biliary ducts, and in cases of calculus and malignant obstruction it may attain a very considerable size, so as to resemble in calibre the small or even the large intestine.

The relations of the common bile duct are of extreme importance in view of the various operations which are performed for the relief of obstruction in the duct.

The supraduodenal portion measures from 10 to 14 millimetres in

length, though it may be shorter or longer, according to the point of junction of the hepatic and cystic ducts. It runs in the free border of the gastro-hepatic omentum immediately in front of the foramen of Winslow. Here it lies on the antero-external aspect of the portal vein, while the hepatic artery is to its inner side. A small branch of the pancreatico-duodenal artery crosses part of the duct just above the duodenum. A chain of three or four lymphatic glands lies in contact

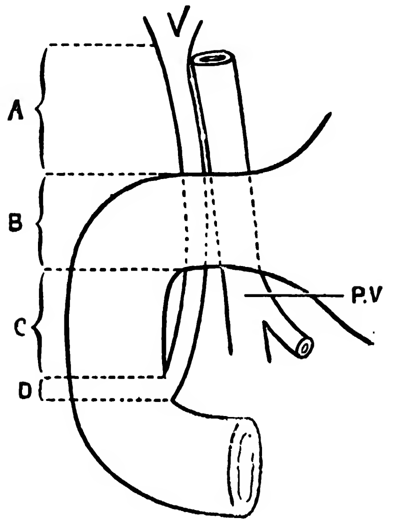


FIG 26. DIAGRAM TO SHOW THE FOUR DIVISIONS OF THE COMMON DUCT. A, The supraduodenal; B, The retro-duodenal; C, The pancreatic; D, The intraparietal.

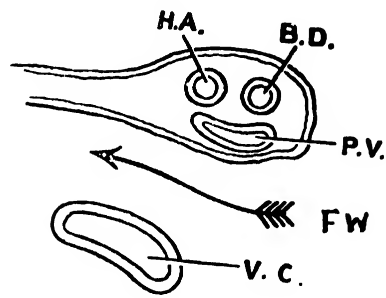


FIG. 27. DIAGRAM TO SHOW THE RELATION OF THE COMMON BILE DUCT IN THE FREE BORDER OF THE LESSER OMENTUM. B.D., Bile duct; F.W., Foramen of Winslow; H.A., Hepatic artery; P.V., Portal vein; V.C., Vena cava.

with the supraduodenal portion of the common bile duct, their vessels passing to the glands in the transverse fissure of the liver.

The retroduodenal portion corresponds to the posterior aspect of the first part of the duodenum, to the wall of which it is closely applied. The portal vein lies to its inner side, while behind it is the inferior vena cava.

The pancreatic portion is the name applied to that portion of the common bile duct which extends from the inferior border of the first part of the duodenum to the point where the duct penetrates the wall of the second part; it measures from 20 to 25 millimetres in length. This portion of the common duct crosses a small quadrilateral area, bounded above by the inferior border of the first part of the duodenum, below by the superior border of the third part, externally by the internal

border of the second part, and internally by the superior mesenteric vein. It is here closely applied to the pancreas, in some cases being completely surrounded by pancreatic tissue, in others lying in a pronounced groove on the posterior surface of the gland.

Bunger (*Med. Press*, 1902, p. 523), in a careful examination of fifty-eight subjects, found in 25 % the duct ran in a groove in the gland, while in 75 % it was completely enclosed by pancreatic tissue.

According to O. Wyss, the common bile duct ran in a groove on the posterior surface of the head of the pancreas in fifteen out of twenty-two bodies examined (68·1 %), and it was surrounded by the tissue of the pancreas on all sides in the other seven bodies (31·7 %). This anatomical condition is important, inasmuch as swelling of the pancreas will in the first case push the common duct out of the way without compressing it, while in the second case compression leading to occlusion may easily take place where the duct passes through the head of the pancreas.

This portion of the common duct is in close relationship with the inferior vena cava.

The intraparietal or interstitial portion of the common duct comprises all that portion of the canal contained in the thickness of the wall of the duodenum. It passes obliquely through the muscular coat of the intestine, and then dilates into a little reservoir underneath the mucous membrane, into which the main pancreatic duct also opens. This is known as the ampulla of Vater. This ampulla, a little oval cavity, may be well seen in a section of the wall of the duodenum in the axis of the common duct (see Fig. 28). The opening of the common duct is above that of the pancreatic duct, and the two are separated by a small transverse fold of mucous membrane. The ampulla measures from 6 to 7 millimetres in length and from 4 to 5 in breadth, and, with the termination of the two ducts, is surrounded by a thin layer of unstriped muscular tissue, forming a sphincter (Oddi). The ampulla opens into the duodenum by a little round or elliptical orifice, which is the narrowest part of the bile channel. It is important to note that the length of the diverticulum of Vater may vary from zero to 11 millimetres, the average being 3·9 millimetres, according to Opie, who measured 100 specimens. Viewed from the interior of the duodenum the ampulla forms a rounded eminence of the mucous membrane, known as the caruncula major of Santorini, the opening being seen at the apex of the caruncle. It is distant 8 to 12 centimetres from the pylorus. Above it there is constantly found a small transverse fold of mucous membrane, which must be raised in order that the caruncle and its orifice may be clearly seen. Running downwards from the caruncle is a small vertical fold of mucous membrane

known as the frenulum carunculæ. Above the caruncula major is found a smaller eminence, the caruncula minor, marking the termination of the accessory pancreatic duct.

An accessory pancreatic duct or duct of Santorini opens into the duodenum about $\frac{3}{4}$ inch above the biliary papilla; it is patent in about 50% of cases, and in over 80% it communicates with the duct of Wirsung.

The mode of formation of the ampulla of Vater and the termination of the common and pancreatic ducts are liable to great variations. Letulle and Nattan Lorrier distinguish four types.

The *first type* is the classical one described above (see Fig. 28).

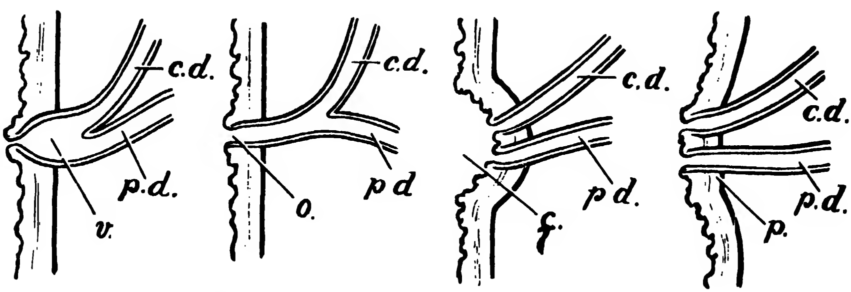


FIG. 28. DIAGRAM TO SHOW THE FOUR CHIEF VARIETIES IN THE TERMINATIONS OF THE BILE AND PANCREATIC DUCTS IN THE DUODENUM. *c.d.*, Common duct; *f.*, Fossa; *o.*, Oval orifice; *p.*, Papilla; *p.d.*, Pancreatic duct; *v.*, Ampulla of Vater.

In the *second type* the pancreatic duct joins the common duct some little distance from the duodenum, the ampulla of Vater is absent, and the duct opens into the duodenum by a small flat, oval orifice.

In the *third type* the two ducts open into a smaller fossa in the wall of the duodenum, while the caruncle and the ampulla of Vater are both absent.

In the *fourth type* the caruncle is well developed, but the ampulla of Vater is absent, its two ducts opening side by side at the apex of the caruncle.

Other variations described in my work on the pancreas so rarely occur that they need not be mentioned here.

In structure the common duct resembles the other biliary ducts, its blood-supply and innervation being the same as those of the hepatic duct.

Congenital malformations. There is apparently no part of the biliary apparatus, except the liver, which may not be absent. While this is not specially to be wondered at in the case of the gall-bladder

and cystic duct, since they are normally wanting in certain animals, and are frequently obliterated by disease in the human subject, it affords serious food for thought to find that life has been possible for six months where even the hepatic and common ducts are represented by mere

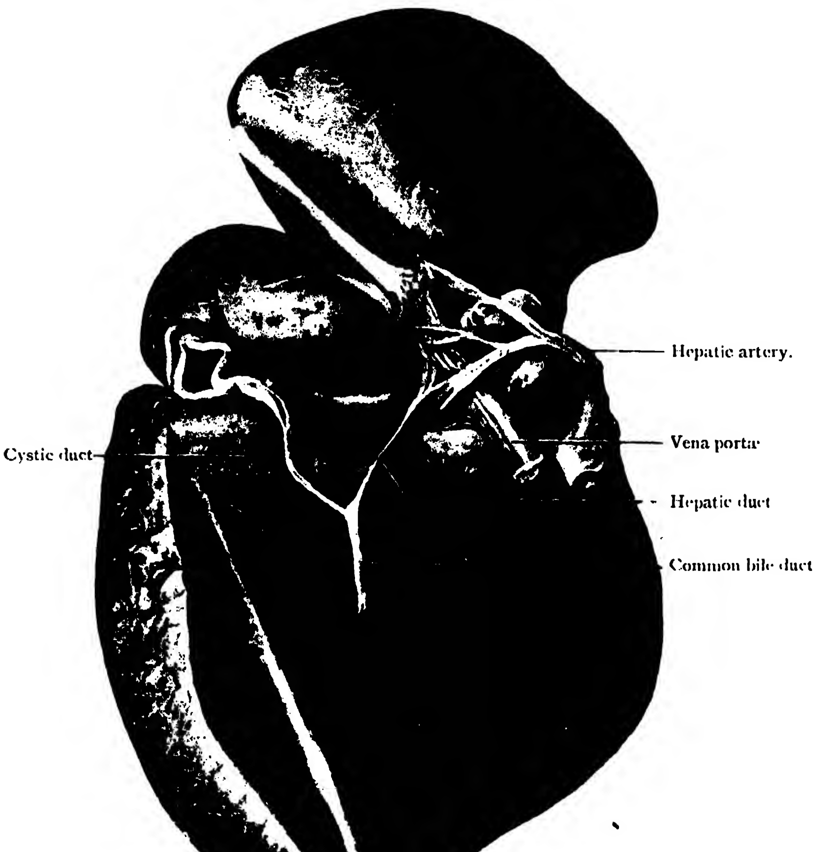


FIG. 29. CONGENITAL OBLITERATION OF THE BILE DUCTS.

fibrous cords (as in Specimen No. 973 (see Fig. 29) in St. Mary's and No. 1017 in King's College Museum).

Hour-glass-shaped gall-bladder is probably not uncommon. I have operated on several.

Occasionally the distal part of the gall-bladder contains calculi, and communicates by a narrow neck with the cyst proper, or the distal portion may simply contain mucus and the proximal sac one or more calculi.

In some instances the condition arises from contraction of an

old ulcer, but in others, the mucous membrane being smooth, and showing no evidence of cicatrization, the deformity appears to have been congenital.

In the *Annals of Surgery* for May, 1899, is related a case in which there was transposition of viscera; and as the patient was the subject of gall-stones, cholecystotomy was successfully performed on the left side.

In palpating the common duct for gall-stones, the surgeon frequently feels several more or less hard nodules within the free border of the lesser omentum, by the side or in front of the common duct, and unless it be borne in mind that three or four lymphatic glands normally exist here, they may be apt to mislead, especially as they are not unusually considerably enlarged where there is gall-stone irritation. Frequently they are as large as beans, and at times the size of filberts.

The large peritoneal pouch, bounded above by the right lobe of the liver, below by the ascending layer of the transverse mesocolon covering the duodenum internally, externally by the peritoneum lining the parietes down to the crest of the ilium, posteriorly by the ascending mesocolon covering the kidney, and internally by the peritoneum covering the spine, has been long recognized, but perhaps not sufficiently appreciated in gall-bladder surgery. Mr. Rutherford Morison drew attention to it in a paper in the *British Medical Journal* for March 3, 1894.

It is possible to drain this pouch by means of a long glass tube, but it is safer to make use of a lumbar drain. It is interesting to note that the pouch is capable of holding nearly a pint of fluid before it overflows into the general peritoneal cavity through the foramen of Winslow or over the pelvic brim.

A deformity of the liver, congenital or acquired, may at times lead to a difficulty in diagnosis or in treatment. The common form is a tongue-shaped prolongation of the right lobe, which may project below the costal margin for several inches, and simulate a tumour of the liver or an enlarged gall-bladder.

In some instances the gall-bladder projects beyond the apex of the linguiform projection, in others the dilated gall-bladder lies under cover of the projecting lobe, which is thinned and spread out over it.

In one of my cases the gall-bladder and linguiform process of the liver reached the cæcal region, and the recurrent attacks of pain, associated with local peritonitis and unaccompanied by jaundice, much resembled recurring appendicitis, the point of greatest tenderness being situated midway between the umbilicus and anterior superior spine of the ilium, in which position the incision for the operation was made.

In others, the projection is external to the gall-bladder, which is then found lying on its inner side.

In a case of this kind, where the gall-bladder is contracted and calculi are impacted in the cystic duct, there may be the greatest difficulty in extracting them, owing to a limitation of the space for manipulation caused by the abnormality, unless the liver be lifted up.

I believe that Professor Riedel first described this linguiform projection of the liver, which is sometimes known as Riedel's lobe. It is said to be uniformly due to cholelithiasis, but that it is not always associated with gall-stones my experience in several cases demonstrates.

The liver is sometimes displaced vertically, as in one of my cases, where the incision had to be prolonged quite up to the ensiform cartilage in order to reach the shrunken gall-bladder, lying under cover of the right

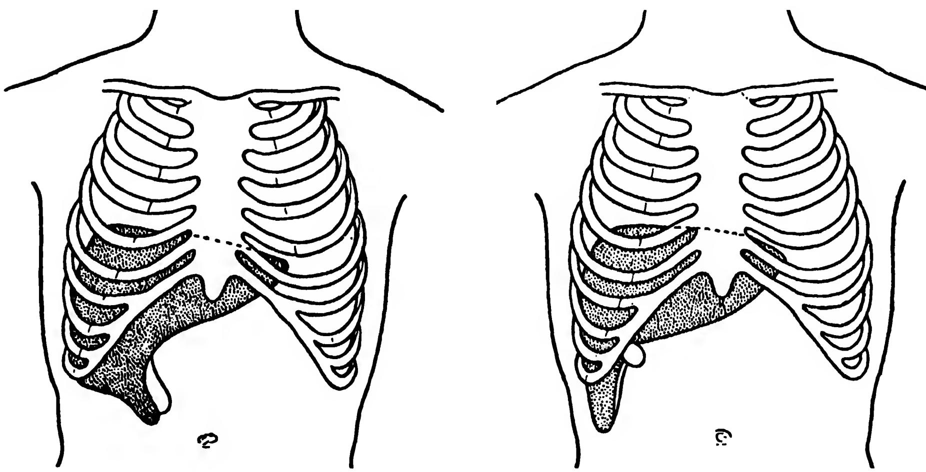


FIG. 30. DIAGRAMS TO SHOW VARIETIES OF THE LINGUIFORM PROCESS OF THE LIVER.

lobe, the under surface of which faced to the left side. In this case the left lobe was much smaller than the right, which formed the great bulk of the liver.

In one case the left lobe was apparently wanting, and the gall-bladder was deeply placed under the right lobe, which faced to the left.

There have been several cases reported where the distended gall-bladder projected into the loin, and was reached and evacuated through a lumbar incision, the condition of liver just described being the probable cause of the distortion.

Dr. J. F. Baldwin of Columbia, Ohio, has furnished me with the notes of a case that came under his care in which the liver was malformed, there being practically no left lobe, and the gall-bladder, instead of occupying the usual position on the under surface of the right lobe, passed

downwards and backwards, and lay just to the right of the vertebral column, in which situation it was opened with difficulty for the removal of gall-stones, and drained. I have myself seen and operated on a similar case.

GENERAL REMARKS ON OPERATIONS FOR GALL-STONES

No surgeon should attempt the removal of gall-stones unless he is prepared for any of the various operations on the biliary passages, such as choledochotomy or cholecystectomy, as it is almost impossible to say beforehand what may be required until the ducts have been explored by the fingers and the condition of the affected viscera ascertained ; and no operation should, as a rule, be concluded until it is clearly made out that the ducts, including the hepatic and common, are free from concretions, otherwise disappointment and dissatisfaction are certain to follow.

Since in the majority of cases, then, an operation for gall-stones is in the first place simply exploratory, the actual operation on the gall-bladder or bile ducts being only determined by the condition found when the abdomen is opened, it may be well first to consider a simple abdominal section in the gall-bladder region.

Preparation for operation. First, as to *the room* in which the operation has to be performed. Any ordinary well-cleaned room having high windows so as to give good top light answers almost as well as an operating theatre. There is, of course, an advantage in having an overhead electric light, but the operation now performed on the bile passages is, with few exceptions, done close to the surface, not as formerly at a great depth, which necessitated a special electric lamp, and always a very good vertical or high oblique light.

The advantage of operating in a hospital or surgical home is that the surgeon, or his house surgeon or assistant, is responsible not only for the operation but also for the after attendance, a matter almost as important as the operation itself. Moreover the surgeon can do his work better and with greater confidence where he is accustomed to operate, and where he is confident that all his directions before, at the time, and subsequently, will be carried out to the letter.

In this matter of where the operation should be done, the surgeon who has to do the operation ought to make the selection, and the patient should abide by the decision with the full confidence that the operator will select the place where he can do his work to the best advantage of the patient.

I have seen several unsatisfactory cases in which patients insisted on having operations performed in their own homes, which were utterly

unsuitable for such a purpose, that would in all probability have done well had they been in a surgical home, where the complications causing the trouble could have had immediate and skilful attention.

The surgeon ought also to be helped by his ordinary *assistant* in all serious operations, for a stranger, no matter how skilled, can never accommodate himself immediately to the needs of the operator, and it must be remembered that surgery is a fine art, that can only be carried out with the greatest perfection under circumstances that are favourable to the operator.

The selection of the *anæsthetist* should also be with the operator, for with a competent anæsthetist the surgeon can devote the whole of his mind to his own part of the work in hand, without having his attention diverted to make suggestions concerning the anæsthetic.

With regard to *instruments*, a gall-stone scoop and curved clamps are the only special appliances required, and all the instruments are boiled for half an hour before being used.

My *sutures* and *ligatures* are of catgut prepared by the iodine process; they are strong and reliably aseptic. I have given up the use of silk sutures in gall-bladder surgery, and where a more durable stitch is required I employ 0 or 00 size of green chromic catgut, which answers equally well, as it does not become absorbed before the second or third week. As showing the disadvantage of non-absorbable sutures, there have been several cases recorded in which the knot of a ligature formed the nucleus of a gall-stone that had to be removed by operation, and one in which a silk suture used in a choledochotomy formed the nucleus of another gall-stone, which fortunately passed without further operation.

As *sponges*, sterilized gauze swabs are used, but for isolating the area of operation thicker swabs with a tape attached are employed. The area of operation is surrounded by dry sterilized towels or a perforated sheet, sterilized by superheated steam for half an hour.

My assistant and I wear boiled rubber *gloves*, and near the operating table I keep a bowl of 1 in 2,000 mercury biniodide solution or a normal saline solution in order to lave the gloved hands from time to time during the course of the operation. The instruments are used out of plain boiled water and the swabs are either used dry or wrung out of a hot normal saline solution. The ligatures and sutures are used out of a receptacle containing plain boiled water.

The patient is prepared by having an aperient given so as to secure the bowels being moved the day before operation, and an enema is given the evening before if the operation is to take place early the next morning. If there be any feebleness of pulse, 5 minims of liquor strychninæ are given subcutaneously on the afternoon and evening of the day before

operation and 5 minims as soon as the operation is nearing completion. Should there be chronic jaundice or a tendency to hæmorrhage, calcium chloride is given; for although there is a greater tendency to bleeding in chronic jaundice from pancreatic disease than when jaundice is due to gall-stone obstruction, there can be no doubt that in all cholæmic conditions the blood becomes so altered that the coagulability becomes seriously diminished. Hence, in operating on deeply jaundiced patients, either an injection of normal serum should be given a few hours before operation, or chloride of calcium may be administered in two 30-grain doses by the mouth the day preceding operation, and afterwards in 30-grain doses by the rectum daily for two days, if needful.

The skin of the patient over the operation area is prepared the day before, by thoroughly washing with ether soap; if needful, shaving is then done. A dressing of lint, wet with 1 in 1,000 solution of biniodide of mercury in methylated spirit, is then applied, and over this oiled silk or gutta-percha tissue. The dressing is then changed early the next morning and the skin is thoroughly washed, so as to clear away all loose and sodden epithelium, after which another dressing is applied, to be removed on the operating table.

If the patient be feeble, a pint of normal saline solution with an ounce of brandy is given *per rectum* a short time before the operation.

As shock is intensified by exposure to cold, my patients are always enveloped in cotton-wool, which is conveniently done by making a suit of gamgee tissue that can be readily run together by the nurses in a hour or two the day before operation.

It will be found that a firm sand-bag, about 18 inches long by 6 inches wide and 3½ inches deep, warmed and covered with flannel, and placed on the operating table at the liver level, will push the spine forward, and with it the liver and bile ducts, so that the common and hepatic ducts are brought several inches nearer the surface. By opening out the costal angle and tending to make the intestines slip down from the liver, it acts like the Trendelenburg position in pelvic surgery.

An inflatable rubber bag may be employed in place of the sand-bag if preferred, or a firm roll of towels will answer if other appliances are not at hand.

Though this method, until I drew attention to it, does not seem to have been employed by others, I can from ample experience speak well of its great utility. Instead of the sand-bag, I have, during the past two or three years, been employing a table, which by a slight mechanical act elevates the hepatic region with facility, and this without disturbing the patient or deranging the aseptic surroundings.

Operation. Whereas I used formerly to make a vertical incision through the linea semilunaris, I now always make my incision over the middle of the right rectus in a line parallel with its fibres, which are then separated by the finger, the posterior sheath of the rectus and peritoneum being divided together. Where the gall-bladder is distended and there is no jaundice, a small incision of 2 or 3 inches only may be required; but when it is necessary to explore either the hepatic, common, or deeper part of the cystic duct, instead of prolonging the incision downwards as was formerly done, I now carry it upwards obliquely as high as possible in the interval between the ensiform cartilage and the

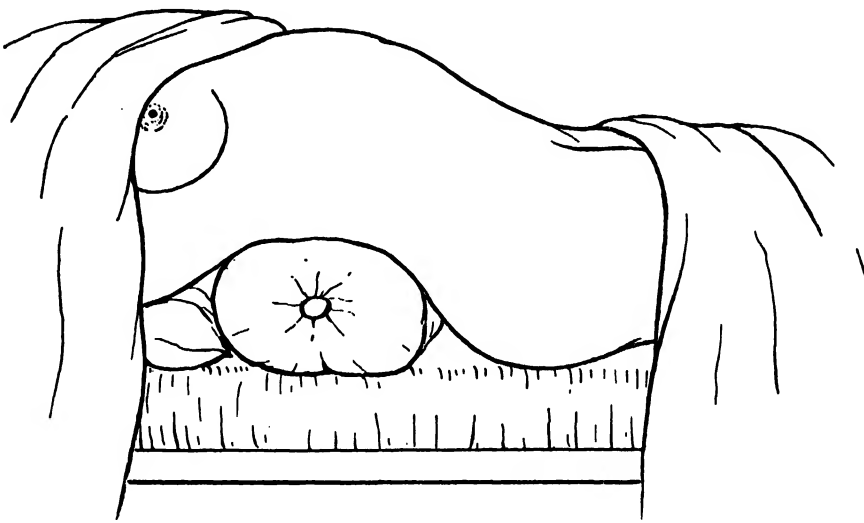


FIG. 31. DIAGRAM TO SHOW SAND-BAG OR CUSHION PLACED UNDER THE BACK TO RENDER PROMINENT THE LIVER AND BILE DUCTS.

right costal margin, thus freely exposing the upper surface of the liver. In some cases I have displaced the rectus inwards or outwards instead of splitting the fibres, as in the operation for removing the appendix. It will be found that by lifting and rotating the lower border of the liver (if needful first drawing the organ downwards from under cover of the ribs) the whole of the gall-bladder and the cystic and common ducts are brought quite close to the surface, and as the gall-bladder is usually strong enough, an assistant can take hold of it with his fingers or forceps and by gentle traction can keep the parts well exposed, at the same time that, by means of his left hand with a large moist swab under it, he retracts the left side of the wound and the viscera, which would otherwise fall over the common duct and impede the view.

It will now be observed that, instead of the gall-bladder and cystic duct making a considerable angle with the common duct, an almost straight passage is found from the fundus of the gall-bladder to the entrance of the bile duct into the duodenum, and if adhesions have been thoroughly separated, the surgeon has immediately under his eye the whole length of the ducts with the head of the pancreas and duodenum. So complete is the exposure that, if needful, the peritoneum can be incised over the free border of the lesser omentum and the common duct separated from the hepatic artery and portal vein, though this is not necessary

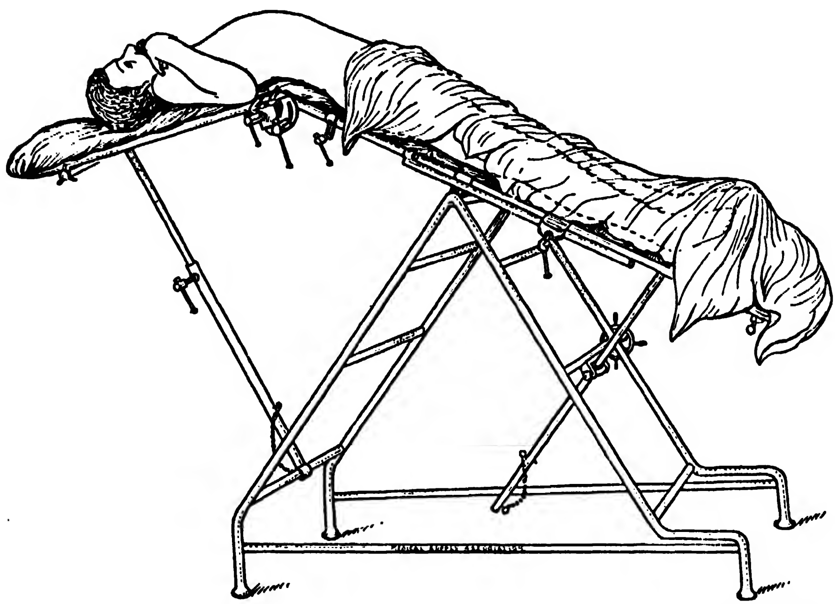


FIG. 32. DIAGRAM TO SHOW THE TABLE EMPLOYED BY THE AUTHOR FOR ELEVATING THE HEPATIC REGION.

except where a growth has to be excised. The surgeon, whose hands are both free, can now deal with the gall-bladder and cystic, common, and hepatic ducts quite easily, and it is safe to affirm that there is no portion of the gall-bladder and cystic, common, or primary division of the hepatic ducts which cannot under ordinary circumstances be reached for the removal of concretions.

Although there is seldom any fear of leakage or of infection, yet, where the ducts have been incised and extensive adhesions separated, there usually is some tendency to pouring out of fluid in the first few hours. I therefore generally insert a gauze drain through a drainage tube passed into the right kidney pouch, bringing it out through a stab

puncture 3 or 4 inches away from the chief incision, towards the right loin; thus dependent drainage is obtained and the anterior incision can be securely closed. This drain is usually removed within forty-eight hours (see Fig. 43, p. 122).

The wound is closed by continuous catgut sutures, first to peritoneum and deep rectus sheath, and next to the anterior rectus sheath. Lastly, the skin margins are brought together by means of two or three interrupted silkworm-gut sutures inserted quite an inch from the line of incision, taking up the anterior rectus sheath and being brought out an inch beyond the incision on the other side so as to allow the edges to fall together without tension, the skin between the sutures being accurately brought together by Michel's metal clips, thus securing union by first intention.

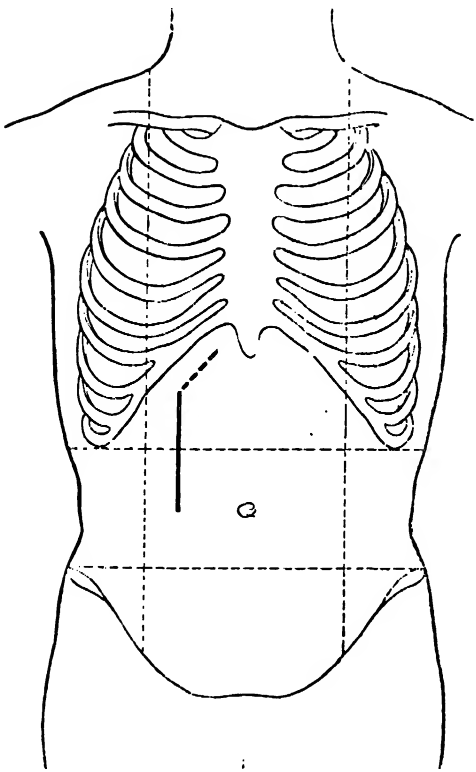


FIG. 33. DIAGRAM TO SHOW THE USUAL INCISION EMPLOYED BY THE AUTHOR. The dotted line shows the direction in which the incision may be conveniently extended when it is necessary to expose the common duct.

If the wound is a large one or the patient is feeble or has a cough, or if there is any fear that the edges of the tissues have been contaminated by the infected bile, the two or three silkworm sutures above referred to, instead of simply taking up the skin and superficial structures only, are made to transfix all the tissues; but these do not in any way alter the arrangements of the continuous catgut suture.

To those having little experience in these operations, the modifications I have employed may seem trivial, but to those who have experienced the difficulties of the ordinary operation of removing gall-stones from a contracted gall-bladder, or from the cystic or common ducts, I feel sure the method described, which enables the whole of the bile passages to be dealt with as a straight line close to the surface, will be sufficiently appreciated.

In these operations, forcipressure is employed for the immediate arrest of hæmorrhage, but I find it is more satisfactory also to ligature all bleeding points, as in jaundiced cases the compressed and unligatured vessels are apt to bleed subsequently and to lead to complications that are avoidable by careful hæmostasis. For the same reason, I prefer

FIG. 34. DIAGRAM TO SHOW THE AUTHOR'S METHOD OF COMPLETELY EXPOSING THE GALL-BLADDER AND BILE DUCTS.

to divide and ligature firm, visceral, especially hepatic, adhesions, where that is practicable, rather than as formerly to separate them with the finger or tear them through.

If the liver be torn in separating adhesions, the bleeding must be carefully arrested before the abdomen is closed. Sponge pressure is usually sufficient if the laceration be small, but if the laceration be extensive, deep catgut sutures applied by means of a round intestinal needle will usually accomplish the desired effect; or, this

failing, gauze pressure is employed, the plug being left in until it becomes loose.

After-treatment. Expedition in operating is an important factor in lessening shock, especially in abdominal surgery, for it stands to reason that prolonged manipulation and exposure of the viscera, in patients so ill as the class of cases we are now considering must generally be, will be badly borne; for it is not only the work of the surgeon but the deep anæsthesia that adds to the shock, since for these operations to be expeditiously performed the muscles must be well relaxed. Choledochotomy should occupy from half an hour to an hour, and only in case of unusual complications a little longer.

After operation, a pint of saline fluid with 1 ounce of brandy is given by enema, and 5 minims of liq. strychniæ are given subcutaneously, this being repeated if called for. Subcutaneous injections of saline fluid or intravenous infusion are only rarely required. The saline enema, with an ounce of liquid peptonoids and an ounce of brandy, is repeated in two hours and again in four hours.

Beyond a teaspoonful of hot water or hot tea or albumen water from time to time, all feeding is by the rectum for the first twenty-four hours, though if there be no vomiting the teaspoonful of water is increased to a tablespoonful, or even two, every hour or oftener. After forty-eight hours, if there be no vomiting, milk and soda and barley-water can be freely given. A little plasmon dissolved in the tea or beef-tea or barley-water considerably adds to the nutritive value of the fluid. Light custard pudding is usually given on the third or fourth day, fish on the fifth, and chicken on the sixth, after which the diet becomes almost normal.

The bowels are not disturbed before the fifth or sixth day, and then only by enema, unless there is vomiting or distension, and in case of either of these complications a grain of calomel is administered and followed by 2 ounces of apenta water every two hours until it acts or flatus passes freely, this being helped by the rectal tube or by a turpentine enema or by a soap and water enema containing 10 minims of oil of cajuput.

Morphine is avoided after all my abdominal operations, as it tends to paralyse the intestines and leads to an accumulation of flatus. I believe that abstention from the use of morphine is a great feature in the success of abdominal surgery, just as I feel sure that in the past it has killed many patients who would otherwise have done well.

If a sedative be needed, 5 or 10 grains of aspirin will be found useful, and this can be repeated in two hours if required. In case of vomiting being troublesome or epigastric distension persisting, gastric lavage

will be found useful, and when the stomach is emptied, a dose of apenta water may be left in it to incite peristalsis. Under these circumstances no food or fluid is allowed by the mouth, but plenty of fluid in the shape of normal saline is given by rectum.

After all my abdominal operations I am accustomed to place the patient in the position shown in the accompanying drawing. It not only is a comfort to the patient immediately after operation, but prevents lung complications and in the later stages shortens the time of conva-

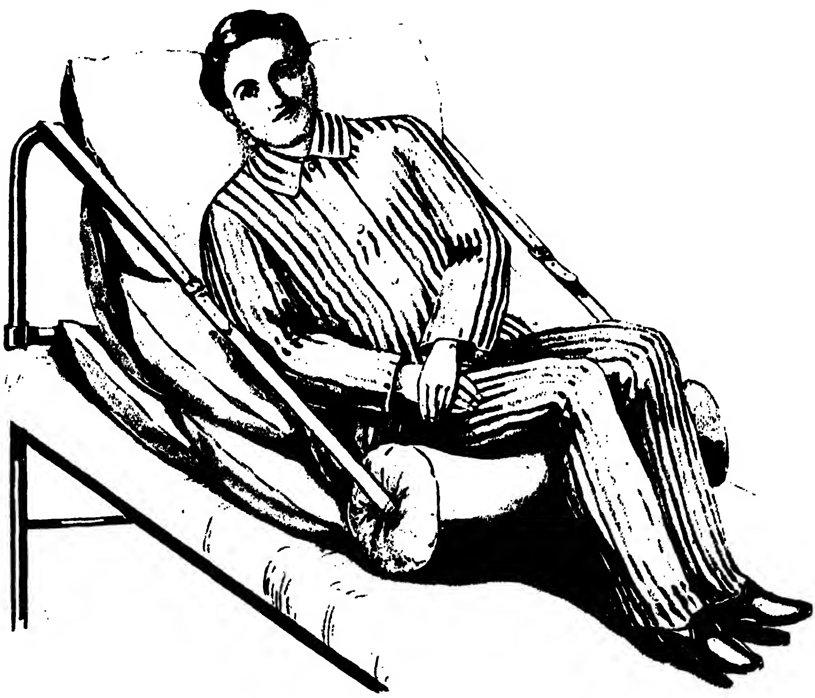


FIG. THE SLING PILLOW.

lescence. The sling pillow, which was invented by Mr. J. A. C. Forsyth, renders it easy to retain the patient in position (see Fig. 35).

As a rule recovery is uneventful, and for the most part after-treatment is negative. The stitches are removed on the eighth day and the tube usually comes away about the same time; the wound generally will have healed by first intention, and the spot where the tube was heals by granulation. The dressings are of the simplest—sterilized gauze and sterilized cotton-wool being employed as a rule, double cyanide gauze being sometimes used next to the wound.

OPERATIONS FOR PERFORATION OR RUPTURE OF THE GALL-BLADDER OR BILE DUCTS

Operation in perforation from disease. If, unfortunately, in inflammation of the gall-bladder or bile ducts the disease be allowed to progress to rupture before surgical treatment is adopted, as soon as it is clearly made out that perforation has occurred, or even if it be only suspected that such is the case, the abdomen should be opened by a vertical incision through the right rectus above the umbilicus.

FIG. 36. LACERATION OF THE GALL-BLADDER. Drawing of Specimen No. 2267, St. Bartholomew's Museum. Showing a laceration $\frac{3}{4}$ inch long in a gall-bladder previously dilated as the result of a gall-stone lodging at the entrance to the cystic duct. The specimen is from a man of fifty who was kicked when stooping.

If pus and bile be found they should be rapidly wiped away with gauze swabs, and if the extravasation has become general, the abdomen may be flushed with hot sterilized saline solution.

In draining, it should be borne in mind that the right kidney pouch (see Fig. 43) forms a distinct peritoneal pocket, and that a drainage tube applied through a stab opening in the right loin affords a free exit for extravasated fluids coming from the neighbourhood of the gall-bladder. If the whole peritoneal cavity has been soiled, a puncture above the pubes large enough for a tube to be passed into the pouch of Douglas will be an advantage.

At the same time it will be wise to drain the gall-bladder or bile ducts either through the perforation or through a separate cholecystotomy opening, but should marked cholecystitis be found, the question of performing cholecystectomy may have to be considered if the patient be in a condition to bear the operation. If, however, the patient be in a critical condition it is a mistake to attempt too much, and possibly cleansing and free drainage will only be necessary or advisable at the time, the removal of the cause being left until the patient is better able to bear a more prolonged operation.

After operation the patient must be propped up in bed or turned to the right side to allow of dependent drainage.

Operation for injury. *In the case of penetrating wounds*—if seen early—immediate operation is called for in order to repair the injury and drain the right kidney pouch. In case of laceration of the gall-bladder, cholecystotomy or cholecystectomy is advisable, according to the extent and nature of the laceration.

FIG. 37. RUPTURE OF THE GALL-BLADDER. Drawing of Specimen No. 2268, St. Bartholomew's Museum. Showing a rupture of the fundus of the gall-bladder caused by a fall on a piece of timber. Bile escaped into the peritoneum and death from peritonitis followed after five weeks.

FIG. 38. PERFORATION OF THE GALL-BLADDER. Drawing of Specimen No. 2268 a, from St. Bartholomew's Museum. Showing a perforating wound of the gall-bladder from a boy of fifteen who fell from a load of hay on to a pitchfork. Death occurred after five days from peritonitis with extravasation of bile.

If the common duct be lacerated, suture may be possible, or failing that, a drainage tube may be inserted into the duct. In complete rupture of the common duct, Terrier has suggested ligature of both ends of the laceration and the performance of cholecystenterostomy.

In case of laceration of the hepatic duct, suture may be impracticable and drainage of the duct only possible, but whether or not suture can be

performed, the right kidney pouch must be drained through a stab wound in the right loin.

In subcutaneous rupture without external wound, if the diagnosis be made early, and in all cases where the bile is infected, exploratory laparotomy with free drainage of the right kidney pouch is imperative. If the whole peritoneal cavity has been soiled, a glass tube should also be passed through a stab wound over the pubes so as to drain Douglas's pouch, and the patient should then be fully propped up in bed; this position being retained by the sling pillow shown in Fig. 35.

If the operation be performed before adhesions have developed, the injury should be repaired, but if adhesions have formed and extravasation is limited to the right side, free drainage of the right kidney pouch and right-sided decubitus should alone be adopted, leaving the closure of the wounds to nature's efforts.

Secondary laparotomy will usually be called for in cases of subcutaneous rupture, owing to the difficulties in diagnosis until jaundice appears. In many cases it will be impossible to detect the wound owing to the formation of false membrane. In these cases the bile may be washed out with saline solution and the abdomen drained, or simple drainage without lavage may suffice.

If a small wound be found in the gall-bladder, it may be sutured or the gall-bladder may be drained through the opening. If the gall-bladder be extensively lacerated, or if the cystic duct be injured, cholecystectomy should be performed.

Terrier collected twelve cases of secondary laparotomy for injuries to the bile ducts and gall-bladder with six recoveries.

Aspiration alone has been frequently successful where a diagnosis had not been made until the extravasated bile had been shut off by lymph barriers from the general peritoneal cavity.

Courvoisier collected eighteen cases of aspiration, with recovery in eleven. He advocated repeated aspiration before resort to laparotomy.

Terrior and Auvray (*Chirurgie du Foie*) collected seventeen cases in which aspiration (in most cases repeated) had been performed. Of these, ten recovered and seven died.

Occasionally a single aspiration has been successful; more usually multiple aspirations are required before recovery ensues.

CHAPTER II

OPERATIONS UPON THE GALL-BLADDER

CHOLECYSTOTOMY

THE term cholecystotomy is applied to the ordinary operation of opening and draining the gall-bladder. It is available for many of the diseases affecting the liver, pancreas, gall-bladder, and bile ducts, and is unquestionably *the* operation to be aimed at in the greater number of cases of cholelithiasis, the operation of cholecystectomy being reserved only for the special conditions mentioned later.

Indications. Cholecystotomy is indicated—

(i) In operating for gall-stones in the gall-bladder, when it has sufficient capacity to permit of drainage and is otherwise not seriously damaged.

(ii) In operating for gall-stones in the cystic duct, if the duct be free from ulceration and is not strictured.

(iii) In operating for gall-stones in the common duct after the removal of the concretions by choledochotomy, if the gall-bladder be not seriously diseased and the cystic duct is patent and not ulcerated.

(iv) In chronic catarrh of the gall-bladder and bile ducts producing attacks resembling gall-stones, after failure of general treatment.

(v) In simple empyema of the gall-bladder, when the walls of the gall-bladder are not seriously damaged.

(vi) In infective and suppurative cholangitis, after removal of the cause, if that be possible.

(vii) In hydatid disease of the liver discharging into the ducts, cholecystotomy will be a necessary part of the operation.

(viii) In hydrops of the gall-bladder, if the gall-bladder be only of moderate size, if the obstructing cause be capable of removal, and if the cystic duct be not ulcerated or strictured.

(ix) In certain cases of jaundice due to inflammation of the head of the pancreas compressing the bile duct, where it is not considered necessary or advisable to perform cholecystenterostomy.

(x) In cancer of the common duct or of the head of the pancreas obstructing the common duct and setting up jaundice, it may occasionally be justifiable to perform cholecystotomy for temporary relief; though

if it can be done quickly and the patient is able to bear it, cholecystenterostomy is the better operat'on.

(xi) In rupture or perforation of the biliary passages from injury or disease, cholecystotomy may be advisable along with other remedial measures.

(xii) In gangrene of the gall-bladder or phlegmonous cholecystitis, only when the patient is so extremely ill that no other operation can be attempted.

(xiii) In infective inflammations of the gall-bladder, as in typhoid fever.

The operation is contra-indicated—

(i) As a rule in gangrenous or phlegmonous cholecystitis, unless the patient be so extremely ill that cholecystectomy cannot be undertaken.

(ii) In case of stricture or ulceration of the cystic duct, in which cholecystectomy is indicated.

(iii) In case of stricture or other obstruction of the common duct which it is impossible or impracticable to remove, when cholecystenterostomy is indicated.

(iv) In greatly dilated, or so-called hydrops of the gall-bladder, cholecystectomy is indicated.

(v) In contracted, thickened, ulcerated, or other seriously diseased conditions of the gall-bladder, when cholecystectomy should be performed if the common duct be patent.

(vi) In cancer or other growth of the gall-bladder or cystic duct.

FIG. 39. INFLAMMATION OF THE GALL-BLADDER AND BILE DUCTS IN TYPHOID FEVER. Death in the seventh week. (*No.* 1395, *Guy's Museum.*)

Operation. Nothing can be simpler than an ordinary cholecystotomy with a distended gall-bladder, or even with a gall-bladder of ordinary size, where a small incision suffices to expose the sac, which is emptied by a trochar or aspirator. The collapsed sac is then brought through the wound and surrounded by sterilized gauze. It is then incised through the point where the needle was inserted, and through

the wound in the fundus the gall-stone scoop is inserted, and all gall-stones are removed, a probe or the finger being employed to prove the ducts clear. A firm rubber tube, much firmer than the drainage tubes ordinarily sold, is then inserted from ½ to 1 inch into the gall-bladder, the edges of the incision into the gall-bladder being drawn firmly around it by a catgut purse-string suture, which is tied and cut short, the tube being fixed in position by a fine (size 0) non-chromic, catgut suture, which transfixes the tube and the edges of the incision in the gall-bladder. The gall-bladder is then fixed to the aponeurosis by two catgut stitches, but never to the skin unless a permanent

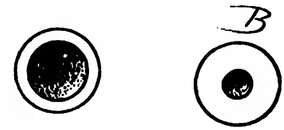
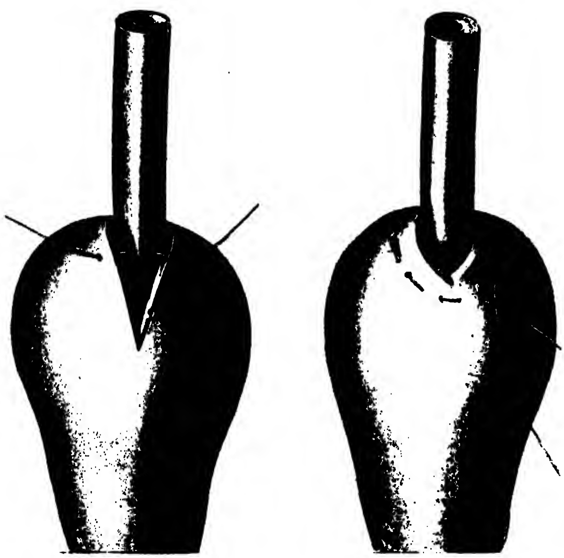


FIG. 40. DIAGRAM TO SHOW THE THICK-WALLED TUBE USED BY THE AUTHOR. A shows the ordinary drainage tube; B shows the thick-walled tube.



A B C

FIG. 41. DIAGRAMS TO SHOW THE METHOD OF FIXING THE DRAINAGE TUBE IN THE GALL-BLADDER AFTER THE OPERATION OF CHOLECYSTOTOMY.

biliary fistula is intended. This tube is sufficiently long to pass into a bottle by the side of the patient; it drains all the bile away from the wound, and by the time the catgut has dissolved, usually on the seventh or eighth day, the wound will have healed by first intention, except where the tube was, and that heals by granulation within the next week or two if the ducts are clear.

This description applies only to operations on a gall-bladder of normal size or to one that is distended, a condition met with in only a proportion of cases in which operation is undertaken for gall-stones. When the gall-bladder is small and situated deeply, or the liver is retracted beneath the costal margin, or when both the gall-bladder and bile ducts are covered in by adherent, possibly distended viscera, and the patient has a considerable development of fat both within the abdomen and beneath the skin, the surgeon must be prepared to face a more difficult operation.

In such cases the modifications described on p. 108 will be found of the greatest service. The position is obtained either by means of a sand-bag or of a special table, and the incision extended upwards obliquely to the notch on the right of the ensiform cartilage will have been employed and the abdomen opened.

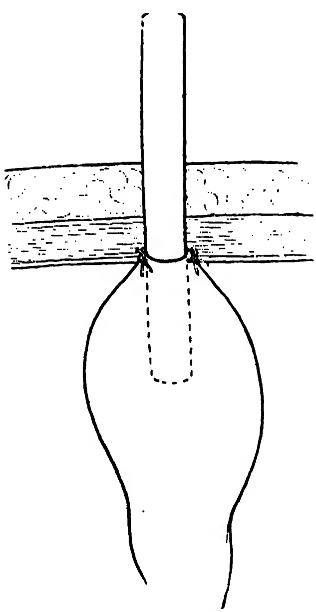


Fig. 42. Fixation of the Gall-bladder to the Abdominal Aponeurosis.

Adhesions must now be separated, and in the case of old omental adhesions to the liver it is safer to ligature them *en masse* or bit by bit, as otherwise bleeding is apt to be troublesome from the torn liver surface.

All vessels must be caught up and ligatured, otherwise blood will collect and obscure the field. The viscera must be handled gently, and in the case of firm and close adhesions between the gall-bladder and colon or duodenum or pylorus, if they do not readily separate by wiping with gauze, it is better to associate digital manipulation with careful dissection until a clear view is obtained of the gall-bladder and cystic and common ducts.

If the liver be of normal size and the adhesions have been detached, or if the right lobe be enlarged, as is so often the case in gall-stone disease, the assistant can easily grasp the free border between his fingers, or take hold of the gall-bladder and draw it forward, thus rotating the liver and bringing the gall-bladder and bile passages well within view (see Fig. 34).

A sterilized gauze swab wrung out of hot normal saline solution is then placed in the wound over the exposed viscera, the gall-bladder being packed off. The edges of the skin and the abdominal wound are also covered with gauze to avoid soiling. The gall-bladder is then

emptied of fluid, if any be present, by means of an aspirator or trochar, great care being taken to avoid escape of fluid which may be septic.

Through the point of the aspirator puncture the gall-bladder is incised, the wound being enlarged sufficiently for the gall-stone scoop to be introduced, and by its means all gall-stones are removed from the gall-bladder and cystic duct, their removal being assisted, if necessary, by the index and middle fingers of the right hand being passed behind the swab so as to press on the cystic duct to extrude any deeply placed concretion.

If a gall-stone be impacted in the cystic duct and cannot be manipulated backwards, the duct, which should be close to the surface if the liver is rotated, must be incised and the stone extracted. A probe can then be passed upwards and downwards in order to ascertain if the gall-bladder and cystic duct are free; and if the latter be free from ulceration and be not strictured, it may be closed by a No. 1 catgut suture to the deeper part of the duct and a No. 0 chromic catgut suture to the peritoneal surface; or, if preferred, interrupted sutures may be employed to close the duct. After exploring the common and hepatic ducts to see that no other calculi are present, a thick-walled drainage tube—for instance, a No. 12 Jaques's rubber catheter—is inserted about half an inch into the gall-bladder through the incision, which is either closed around the tube by means of a purse-string suture of No. 1 catgut, or by interrupted sutures (see Fig. 41, B and C). After the tube has been fixed in by a single suture passing through its wall and through the edge of the gall-bladder incision (see Fig. 42), the liver is allowed to fall back into its normal position, and in case of any soiling of the peritoneum it is wiped out with a swab wet with normal saline solution. The gauze swab covering the viscera may now be removed and replaced by a clean one.

If the gall-bladder be of moderate size it will reach the parietes and be fixed to the deep aponeurosis by two sutures as described in a simple operation, but if it be small or contracted it will not reach the parietes; in that case the right border of the omentum may be fixed to the gall-bladder by a suture or two so as to make a peritoneal channel to the surface when the tube comes away about the seventh day. This method, which I described some years ago, I have adopted on many occasions with success.

If, however, this should not be practicable, no harm will occur if the incision in the gall-bladder tightly embraces the drainage tube, as adhesions will form within twenty-four or forty-eight hours that will offer an effectual barrier to the escape of bile into the general cavity of the peritoneum. The tube may then be brought out through the primary incision, which is closed around it as described on p. 119.

For some time I have adopted the method of bringing out the tube through a stab wound external to the primary abdominal incision, if there has been any soiling of the right kidney pouch such as to necessitate the use of a drain. The drainage tube or gauze drain is then brought out by the side of the gall-bladder tube, it being changed within twenty-four hours and usually removed within forty-eight hours.

By adopting this method, the primary incision is able to be closed, and healing by first intention ensured, whereas when the double drain

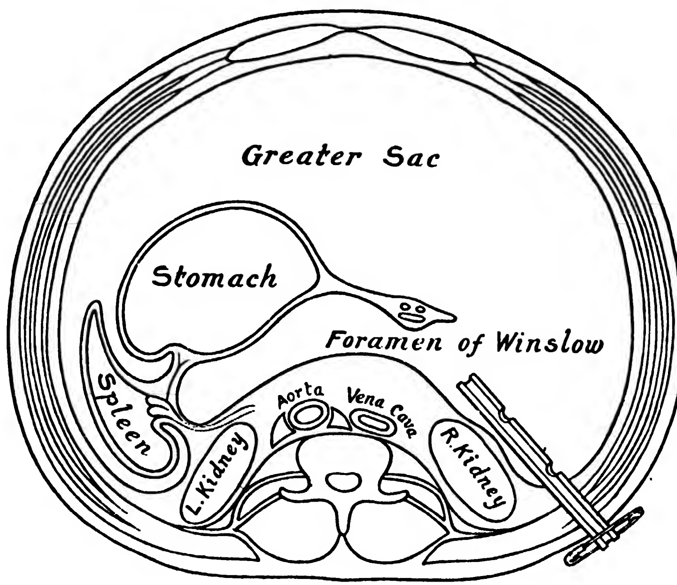


FIG. 43. DIAGRAM TO SHOW THE RIGHT KIDNEY POUCH WITH A DRAINAGE TUBE INSERTED THROUGH A STAB WOUND.

is passed through the wound, infection is likely to occur, involving delayed healing and a weak scar.

Modifications. The operation of cholecystotomy has been modified in several ways; for instance, the opening has been closed by sutures and then fixed to the abdominal incision without drainage, the abdominal incision being closed over it. This is known as *cholecystendysis* (Courvoisier).

Langenbach suggested the so-called *ideal operation*, in which the incision into the gall-bladder is closed by mucous and serous sutures and the viscus dropped back into the abdomen. The serious objection to this operation is that the benefits of drainage are not obtained as in the ordinary operation of cholecystotomy, for it should not be lost sight

of that gall-stones are always associated with catarrh or more active inflammation of the bile passages which is cured by drainage. Another serious objection to this method is that it is decidedly more dangerous than the ordinary operation.

Another modification suggested by Bloch is that *in two stages*. The operation consists in incising the parietes until the peritoneum is reached, the cavity of which, however, is not opened; the wound is then packed with gauze and left for several days, when adhesions will have formed between the gall-bladder and the parietal peritoneum. The gall-bladder can then be safely opened. Or if the peritoneum be incised, the gall-bladder is fixed, but not opened until adhesions have formed.

As the method is only available for the simplest cases, *viz.* where the gall-bladder is distended, as it does away with all chance of exploring the ducts by the hand within the abdomen, and as it is frequently followed by fistula, it needs only to be mentioned to be condemned as clumsy and uncertain, and no safer than the ordinary operation of cholecystotomy.

To this opinion there may possibly be one exception—the operation *à deux temps* might possibly present advantages when cholecystotomy is being undertaken in the presence of chronic jaundice associated with a hæmorrhagic tendency and a distended gall-bladder in a patient extremely ill, as in such cases there is usually malignant disease either of the head of the pancreas or of the bile ducts; and when the peritoneum is exposed, but not opened, pressure can be applied to arrest the subsequent oozing of blood, which cannot always be prevented by ligatures or forceps. Bloch, however, in his original papers, and again in the *Revue de Chirurgie* for 1895, does not recommend the operation for this reason, but on account of the fear of septic contamination of the peritoneum, which ample experience proves to be groundless.

Results. Cholecystotomy or cholecystostomy is the safest operation on the gall-bladder as regards immediate mortality, and cannot be objected to on account of recurrence of gall-stones, which the experience of Mayo, Kehr, myself, and other surgeons shows to be extremely rare.

For statistical purposes the only classification it seems to me fair to make is into simple and malignant, for it must be generally acknowledged that the mortality of any operation must be considerable in such cases as cancer of the pancreas and common bile duct in which the only chance of giving even temporary relief may be by cholecystotomy.

In over 3,000 cholecystotomies performed by Mayo, Kehr, and myself in non-malignant disease, the mortality has been 1·8%, whereas when the operation has been performed for the relief of malignant disease the death-rate has been considerable, from 10% to even 30% or 40%.

CHOLECYSTECTOMY

Many surgical advances, especially in recent years, have been carried out with more zeal than discretion, and in several well-known instances the bounds of good judgment have at first been far passed, though ultimately moderation has prevailed. I here beg to offer a protest against the indiscriminate removal of the gall-bladder in all cases in which an operation on the bile passages is called for.

In 1904, at a meeting of surgeons in America, there was a decided preponderance of opinion in favour of cholecystectomy in all cases in which an operation is necessary for gall-stones, or for any other morbid condition of the gall-bladder, and I know that one or two British surgeons have adopted the same views.

Indications. I know it has been said that the gall-bladder is a useless organ, very liable to infection, whose debased function is that of forming concretions and ultimately becoming cancerous. On the other hand, I would urge, it must not be forgotten that gall-stones, though usually forming in the gall-bladder, may arise in any part of the biliary apparatus, both within and outside the liver; and as a matter of fact, I have seen gall-stones develop in a dilated common duct two years after a cholecystectomy, whereas in the very large experience of myself and several surgeons whose aggregate of cases of operations on the gall-bladder amounts to fully 3,000, it is universally acknowledged that the recurrence of gall-stones after cholecystotomy is an extremely rare event.

Bile is constantly being formed in the liver at the rate of about 1 ounce per hour, as I proved by a long series of observations some years ago (*Proc. Royal Soc.*, vol. xlvii), but it is normally only poured into the intestine after food has been taken and is passing through the pylorus, the sphincter at the orifice of the common duct opening in response to the reflex effect of the stimulus of food passing the pyloric sphincter. In the intervals the gall-bladder acts as a reservoir in storing the bile until it is required to neutralize the acid chyme and to help in emulsifying fat.

While the bile is in the gall-bladder mucus is added to it, and from observations made in 1899 I know that the amount of mucus is considerable, 72 c.c. in twenty-four hours. This serves the purpose of rendering the bile less irritating.

A series of experiments performed by Dr. Flexner demonstrated the fact that if pure bile is injected into the pancreatic ducts it sets up acute pancreatitis, but when bile is mixed with mucus the action is very considerably modified, and when a certain amount of mucus has been added it no longer acts as a serious irritant.

This would seem to prove that the admixture of mucus with bile in

the gall-bladder may be important; and at the best it is merely an expression of ignorance to say that the gall-bladder has no useful purpose to serve.

It is a question whether the loss of the gall-bladder does not lead to a dilatation of the common duct so as to replace to a certain extent the reservoir function of the gall-bladder. That this has occurred in some cases I know from personal experience. If this be universal, it seems not unlikely that after cholecystectomy the dilated common and hepatic ducts may ultimately form a reservoir for the development of concretions. Moreover, if the bile ducts within and outside the liver have to act as reservoirs there must necessarily be back pressure on the secreting part of the liver and possibly biliary absorption, conditions which do not apply when the gall-bladder is acting as a bile store.

Sufficient time has not elapsed to show whether the liver is injuriously affected by this pressure and absorption, as it is only recently that cholecystectomy for almost normal gall-bladders has been adopted by some enthusiasts as a routine procedure.

Whether cirrhosis of the liver and the pancreas will result in a certain proportion of cases remains to be seen.

In ordinary cases of cholelithiasis, cholecystotomy with drainage of the gall-bladder is a very safe and efficient operation, and if the ducts are cleared there need be no fear of fistula or of recurrence of gall-stones. Seeing that cholecystotomy has led to such good results, both immediate and remote, in the surgery of gall-stones, the operation should not be too hastily condemned and replaced by cholecystectomy as a routine procedure. My own experience is that cholecystectomy, though a more prolonged operation than simple drainage of the gall-bladder, can with due care and in experienced hands be performed with hardly more immediate risk (in my last sixty cases only one death), and that when the gall-bladder is contracted and infected, or inflamed and thickened, or gangrenous, or much dilated, it is better to remove it.

I feel sure that if cholecystectomy were to become the routine procedure for inexperienced operators, the death-rate for gall-stone operations would be greatly increased. The rate of mortality shown in some of the recent works on gall-stones does not reflect credit on the hospitals whose statistics are quoted; the mortality of simple cholecystotomy should not exceed at the most 1% to 2%, and will not if due precautions are taken. If, however, these operations be done by inexperienced surgeons who have not taken the trouble to master the technique of the operation and of the after attendance, the mortality will continue to be considerable. But if the mortality of cholecystotomy in inexperienced hands is considerable, what would happen if a consensus of opinion was

allowed to go forth that cholecystectomy is the operation that ought always to be performed for gall-stones? For every surgeon must acknowledge that it is much more difficult to remove the gall-bladder than simply to drain it. I hold that no one ought to do any operation for gall-stones who is not fitted by experience and surgical ability to perform choledochotomy, cholecystectomy, cholecystenterostomy, or any of the more serious operations on the bile ducts, as it is frequently impossible to say beforehand what operation may be required.

Since introducing the method of more completely exposing the biliary tracts when operating for gall-stones, I find no difficulty in deciding as to the bile ducts being quite free from concretions—a necessary condition before cholecystectomy is justifiable.

Seeing that recurrence of gall-stones after cholecystotomy with efficient drainage is an extremely rare event; that the danger of cholecystotomy in uncomplicated cholelithiasis is almost nil—not more than 1 % to 2 % over a large number of cases; that drainage of the bile passages after any gall-stone operation is distinctly advantageous; and that if at some future time it should be necessary to drain the bile passages—say, for obstructive jaundice or interstitial pancreatitis—the difficulties would be increased by the absence of a gall-bladder, though not by a cholecystotomy, my feeling is very decided, that cholecystectomy should not replace the simple operation of cholecystotomy as a routine procedure in operating for gall-stones.

Cholecystectomy is indicated in the following conditions: —

(i) In cancer or other new growth, where the disease is local or limited.

(ii) In contracted and useless gall-bladder, the result of repeated attacks of cholecystitis (see Figs. 44 and 45).

(iii) In dilated or hypertrophied gall-bladder resulting from obstruction in the cystic duct—

(*a*) Always, if resulting from stricture.

(*b*) Usually, if resulting from impacted gall-stones which may have induced ulceration that will subsequently lead to stricture.

(*c*) Usually, if resulting from kinking of the cystic duct or from adhesions.

(iv) In phlegmonous or gangrenous cholecystitis.

(v) In empyema of the gall-bladder.

(vi) In calcareous degeneration of the gall-bladder.

(vii) In mucous fistula of the gall-bladder, the result of stricture or other permanent obstruction of the cystic duct.

(viii) In biliary fistula, when the common duct is free from obstruction.

(ix) In gunshot or other serious injuries of the gall-bladder or cystic duct.

It is unnecessary in ordinary cholelithiasis where the gall-bladder is not seriously damaged and where the cystic duct is not ulcerated or narrowed by stricture; and it is contra-indicated where the surgeon cannot be certain that the deeper bile passages are free from obstruction, unless at the same time the cystic or common ducts be short-circuited into the intestine.

FIG. 44. CONTRACTED GALL-BLADDER. Drawing of Specimen No. 2830 from the R. C. S. Museum. Showing a gall-bladder which has been practically destroyed by ulceration, a gall-stone, the cause of the trouble, being shown in a cavity outside the gall-bladder proper.

The conditions for which cholecystectomy may have to be performed may be conveniently divided into simple and malignant; no other classification seems to me necessary or desirable. In the former class the variety of the conditions for which I have performed the operation is considerable—phlegmonous cholecystitis, gangrene, ulceration, hydrops, perforation, adenoma, cystic disease, hour-glass contraction, inflammatory contraction and calcification of the gall-bladder, simple tumour, ulceration and stricture of the cystic duct, mucous and suppurating fistulæ, rarely biliary fistula, unless at the same time the common duct has been freed from obstruction. In the latter class, cancer, endothelioma, and sarcoma of the gall-bladder or cystic duct.

The after results of cholecystectomy in complicated gall-stone cases have been excellent; instead of prolonged drainage being necessary and a mutilated organ being left, liable to give further trouble, the wound as a rule has pursued an aseptic course, the drain has been removed in twenty-four to forty-eight hours, and primary union has occurred.

The ultimate results have usually been equally good, except in one case where a recurrence of gall-stones took place two years later,

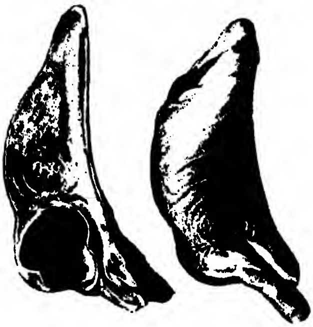


FIG. 45. CONTRACTED GALL-BLADDER WITH STRICTURED CYSTIC DUCT. Removed by the author from a lady, aged fifty-five, on December 1, 1904. She had had attacks of pain over the liver for ten years, and her health had been seriously affected by the repeated seizures. A small cavity in the gall-bladder was connected by a fistula with the duodenum. The patient made a good recovery.

FIG. 46. A GALL-BLADDER WITH GREATLY THICKENED WALLS FROM CHRONIC INFLAMMATION. A calculus of considerable size lies in the fundus, and numerous other calculi are in the gall-bladder itself. Removed by the author. Good recovery.

FIG. 47. INTERSTITIAL HÆMORRHAGE IN THE GALL-BLADDER. Drawing of Specimen No. 2830 K, R. C. S. Museum. A gall-bladder measuring 5 inches in length, which was excised by the author. Its walls are thickened so as to measure about ½ inch and its interior is of a deep black colour from congestion and interstitial hæmorrhage. With the gall-bladder is mounted a mass of exudation which was removed from within it at the operation and in which many small polyhedral calculi are entangled. The peritoneum is intensely congested. Microscopic sections reveal extensive interstitial hæmorrhage into, but no destruction of, the mucosa. Patient well a year later.

FIG. 48. ACUTE INFECTIVE CHOLECYSTITIS. Drawing of Specimen No. 2830 J, R. C. S. Museum. A gall-bladder the walls of which are much thickened from acute infective inflammation, the swelling reaching a maximum of ¾ inch. The mucosa is of a deep brownish-black colour: the peritoneum is intensely and uniformly congested. The gall-bladder contained three large calculi. The deep colour of the mucosa is chiefly due to interstitial hæmorrhage: the lining epithelium has not been shed. The parts were removed from a middle-aged lady on February 20, 1905. On the 17th she had been seized with severe pain in the right side of the abdomen, but until then had had no trouble. When seen her temperature was 104° F., pulse 120. There were signs of peritonitis in the region of the gall-bladder. Operation was carried out on the following morning. A sero-purulent exudation was found in the general peritoneal cavity, and the exterior of the gall-bladder was of a plum colour. The patient made a good recovery after cholecystectomy.

FIG. GALL-STONE IMPACTED IN THE CYSTIC DUCT, CAUSING A BILIARY FISTULA. Drawing of Specimen No. 2830 O, R. C. S. Museum. A gall-bladder with a biliary fistula, showing a gall-stone impacted in the beginning of the cystic duct. From a lady aged thirty-six, who had had cholecystotomy performed in South Africa some months previously during acute cholecystitis, when the gall-bladder had been simply stitched to the surface and emptied. No bile flowed through the fistula until after an attack of vomiting six weeks later, since which time there had been an irregular flow of bile with occasional attacks of pain. The gall-bladder, including the fistula, was completely removed by the author in November, 1904, together with the stone impacted in the first part of the cystic duct. Good recovery followed.

and I had to perform choledochotomy and to drain the common duct.

In the malignant cases operation is necessarily formidable, and unless the disease is strictly localized to the gall-bladder and adjoining part of the liver it is better to stop at an exploratory operation; though I cannot forget that in one of my cases where I removed a portion of the

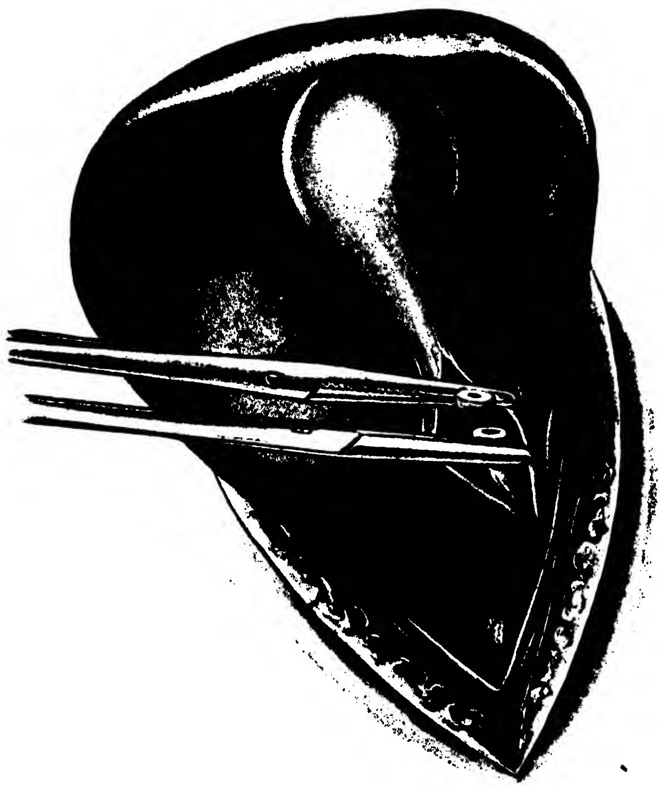


FIG. 50. CHOLECYSTECTOMY. Seizure of the cystic duct.

liver with the gall-bladder, and in another where I removed the pylorus along with a portion of the liver and the gall-bladder, the patients are now living and well, six and a half years and over five years respectively after operation.

Operation. The preparation of the patient and other details, including the first stages of the operation, have been already described on p. 108, the incision being the one shown in Fig. 33.

After separating adhesions, it will be found that by lifting the lower

border of the liver in bulk (if needful first drawing the organ downwards from under cover of the ribs, as shown in Fig. 34, p. 111) the whole of the gall-bladder and the cystic and common ducts are brought quite close to the surface, and as the gall-bladder is usually strong enough, an assistant can take hold of it or the liver with his fingers covered with an aseptic swab, and by gentle traction can keep the parts well exposed,

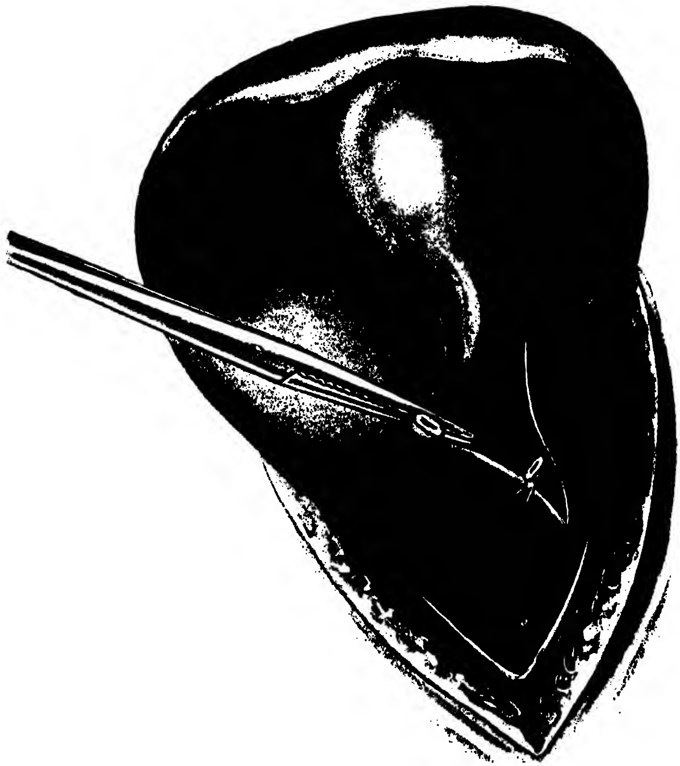


FIG. 51. CHOLECYSTECTOMY. Ligature of the distal end of the cystic duct and commencement of the separation of the gall-bladder from below.

at the same time that, by means of his left hand, he retracts the left side of the wound and the viscera, which would otherwise impede the view.

It will now be observed that instead of the gall-bladder and cystic duct making a considerable angle with the common duct, an almost straight passage is found from the fundus of the gall-bladder to the entrance of the bile duct into the duodenum, and if adhesions have been thoroughly

separated the surgeon has immediately under his eye the whole length of the ducts, with the head of the pancreas and the duodenum. By inserting a gauze pad into the kidney pouch, another into the wound on the left side so as to cover the stomach, and a third below, so as to protect the lower end of the wound, all fear of soiling the peritoneum or the surrounding viscera is avoided.

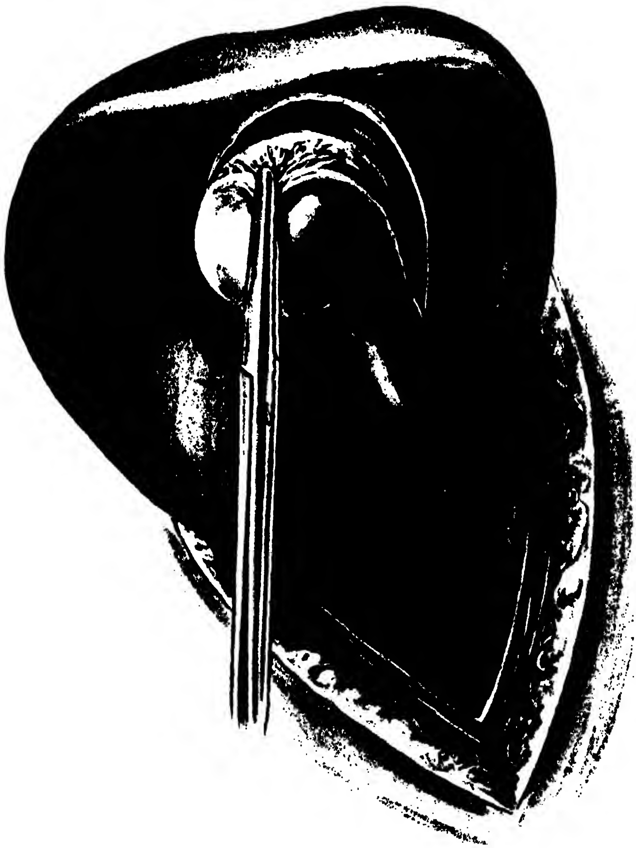


FIG. 52. CHOLECYSTECTOMY. Separation of gall-bladder from above downwards.

After the common and hepatic ducts have been satisfactorily cleared or explored and found to be free from obstruction, the cystic duct is seized a little beyond its entrance into the common duct by means of strong pressure-forceps, which at the same time grasp the cystic artery and thus control bleeding during the remaining stages of the operation. Another pair of pressure-forceps is employed to seize the cystic duct

$\frac{1}{2}$ inch nearer to the gall-bladder, and between the two forceps the duct is divided. The finger or a blunt dissector can now be used to separate the gall-bladder from its bed, and as it is separated the peritoneum on each side is divided by scissors $\frac{1}{3}$ inch from its

FIG. 53. CHOLECYSTECTOMY. Cavity left after removal of the gall-bladder. Ligatured cystic duct about to be buried beneath the peritoneum.

reflection on to the liver, care being taken to avoid wounding the liver. Sometimes it is easier to carry the separation from above downwards, but usually the dissection can be more easily effected from below upwards. Any bleeding points may now be ligatured, and the cystic artery, which was divided between the clamps, can be seen and readily secured by ligature. The open end of the cystic duct is now seized and

ligatured, or stitched up by a fine chromic catgut suture, and the stump is then buried beneath the peritoneum, which is readily brought over it. An ordinary No. 2 iodized, not chromicized, catgut suture is then continued upwards, bringing together the cut peritoneal edges on each side of the gall-bladder fissure of the liver, so as to obliterate the fissure and

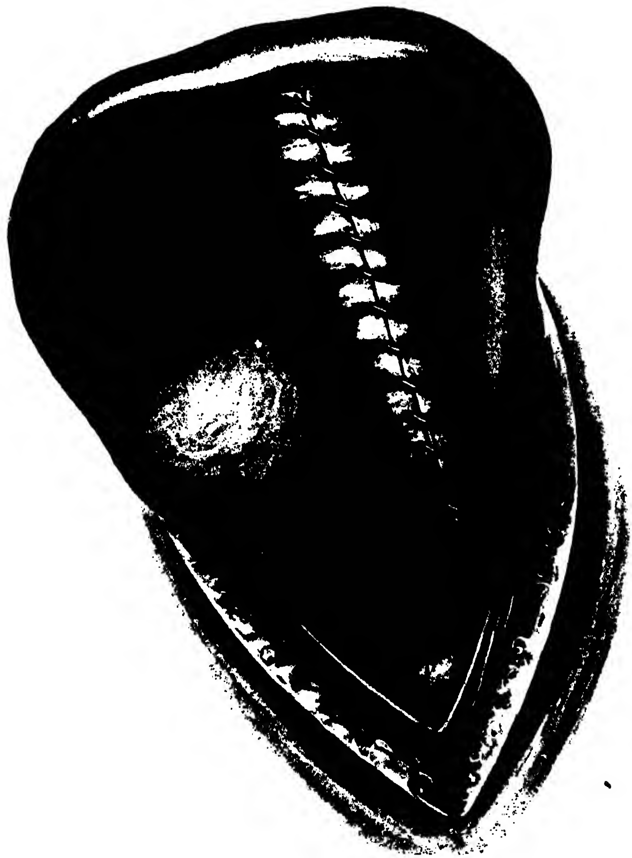


FIG. 54. CHOLECYSTECTOMY. Closure of gall-bladder fissure by bringing together the divided peritoneal edges.

leave no dead space. A gauze drain may be passed down to the duct, but this is not always necessary if the operation has been cleanly conducted; though if the gall-bladder or ducts have been infected and the wound has run any risk of contamination, it will be safer to drain by means of a rubber tube enclosing a thin strip of iodoform gauze. Where there is infection of the common bile duct or of the liver ducts it is

advisable to insert a drainage tube into the divided and open end of the duct, the tube being fixed in place by a catgut suture and surrounded by a purse-string suture of catgut. This will remain *in situ* for a week without any fear of leakage, and by the time the catgut has dissolved a track will have been isolated from the general cavity of the peritoneum,

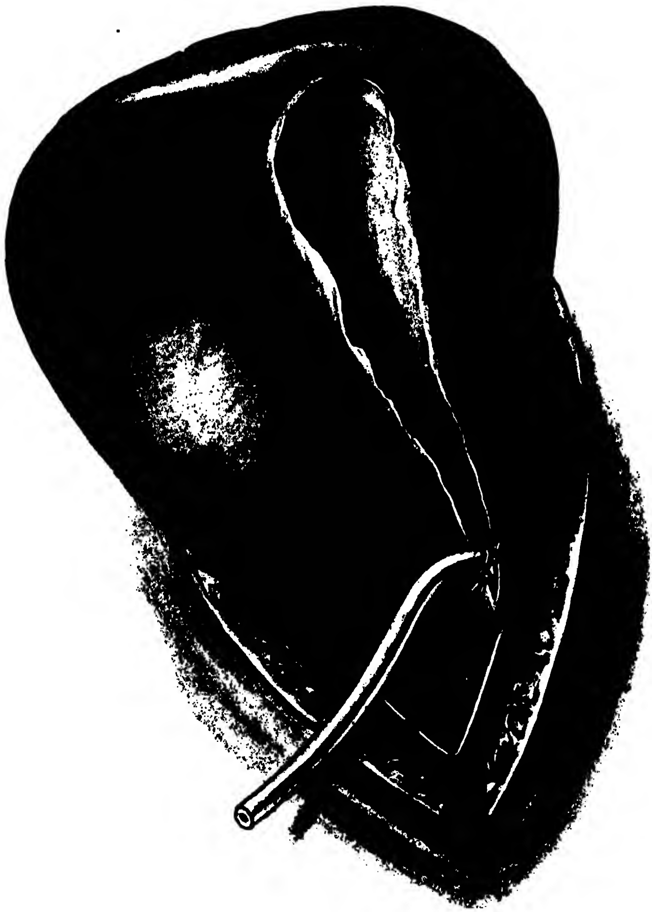


FIG. 55. CHOLECYSTECTOMY. Drainage of the cystic duct.

so that the tube may then be safely removed or left in longer should more prolonged drainage be necessary. The form of tube I usually employ is a No. 12 Jaques's catheter. In order to avoid visceral adhesions I usually bring the right border of the omentum up and place it between the tube and the viscera. It is better to bring this tube, or whatever drain is used, through a separate stab wound external

to the abdominal incision, thus enabling the large incision to be closed securely.

If the patency of the common duct be doubtful, yet the gall-bladder is too badly damaged to be safely retained, the cystic duct may be cut long and the open end anastomosed into the duodenum, either directly by suture or by means of a small decalcified bone bobbin, so as permanently to short-circuit the obstruction. This may be advisable in cases where the pancreas is inflamed and compressing the bile duct.

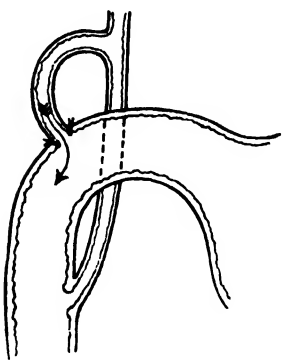


Fig. 56. Cholecystectomy followed by Anastomosis of the Cystic Duct to the Duodenum.

The method of closure of the abdominal wound and other details of subsequent treatment have been described under Exploratory incision.

If the liver be torn in separating adhesions the bleeding must be carefully arrested before the abdomen is closed. Sponge pressure is usually sufficient if the laceration be small, but if the laceration be extensive, deep catgut sutures, applied by means of a round intestinal needle, will usually accomplish the desired effect, or this failing, gauze pressure, the plug being left in until it becomes loose, will be certain to answer.

Results. In about 1,000 cases of cholecystectomy collected from various sources the mortality is close on 5 %, though it is only a little over 2 % in the hands of some operators. In my last eighty cholecystectomies the mortality is just over 3 %, and this includes both simple and malignant cases. In the 1907 report of the Rochester Clinic, U.S.A., the mortality is 3 %.

CHOLECYSTENTEROSTOMY

The operation has for its purpose the establishment of a new channel for the passage of bile from the gall-bladder to the intestine in case of obstruction in the common duct, which it is impracticable to remove by operation.

It consists in establishing an artificial opening between the gall-bladder and some portion of the intestine, preferably the duodenum, though in some cases in which the extreme illness of the patient, the presence of adhesions, or the absence of efficient help render that anastomosis impracticable, the gall-bladder may be more easily united to a loop of the jejunum or even to the hepatic flexure of the colon.

Although the conception of the operation occurred independently

to Harley, Gaston, and Nussbaum, the first operation was actually performed by von Winiwarter of Liége, who completed it in six stages between July, 1880, and November, 1881; my case in 1889 was the first performed in England and was the first cholecystenterostomy performed for the cure of a biliary fistula. The anastomosis was done in one stage and was accomplished by a double row of sutures.

Indications. The operation may have to be undertaken for—

(i) Interstitial pancreatitis which by obstructing the common bile duct leads to chronic jaundice.

(ii) Tumour or cancer of the head of the pancreas.

(iii) Tumour of the common bile duct.

(iv) Rupture of the common duct in which ligature of the duct has been rendered necessary.

(v) Stricture of the common duct following gall-stone obstruction or ulceration.

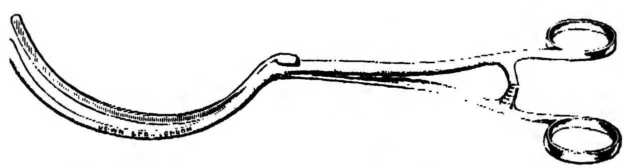


FIG. 57. CURVED FORCEPS USED BY THE AUTHOR IN GALL-BLADDER ANASTOMOSIS.

(vi) Biliary fistula, either following operation or as a sequela of pathological changes in which the obstruction to the bile flow cannot be removed.

(vii) Distended gall-bladder in which drainage is for some cause undesirable and where cholecystectomy is contra-indicated.

Contra-indications. (i) Gall-stone obstruction.

(ii) Small and atrophied gall-bladder.

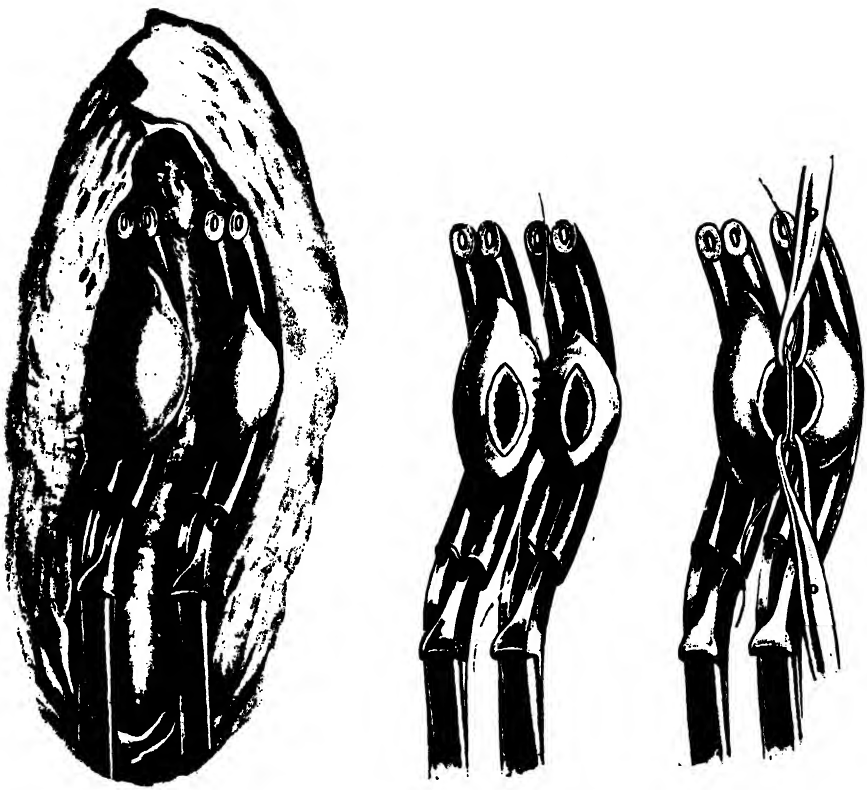
(iii) Obliteration or stricture of the cystic duct with enlargement of the gall-bladder, in which cholecystectomy is indicated.

(iv) Malignant disease of the head of the pancreas or common bile duct leading to distension of the gall-bladder. In this condition the mortality of the operation is so great and the relief in case of recovery of such short duration that the operation is hardly worth performing.

Operation. Having exposed the gall-bladder as already described, and placed the patient in the position shown in Fig. 32, p. 109, the gall-bladder, if distended, must be emptied by trochar or aspirator and the fundus of the empty sac be grasped by the small curved clamps shown in Fig. 57. The duodenum at the junction of the first and second portions must now be mobilized, if necessary, sufficiently to allow of a portion of the anterior wall being grasped in another pair of small curved clamps.

On placing the two clamps parallel the grasped portions of the gall-bladder and duodenum will be placed close together, thus facilitating the application of sutures.

A fine Pagenstecher's thread is first applied, uniting the serous surfaces of the two viscera for at least an inch in length, the needle being then



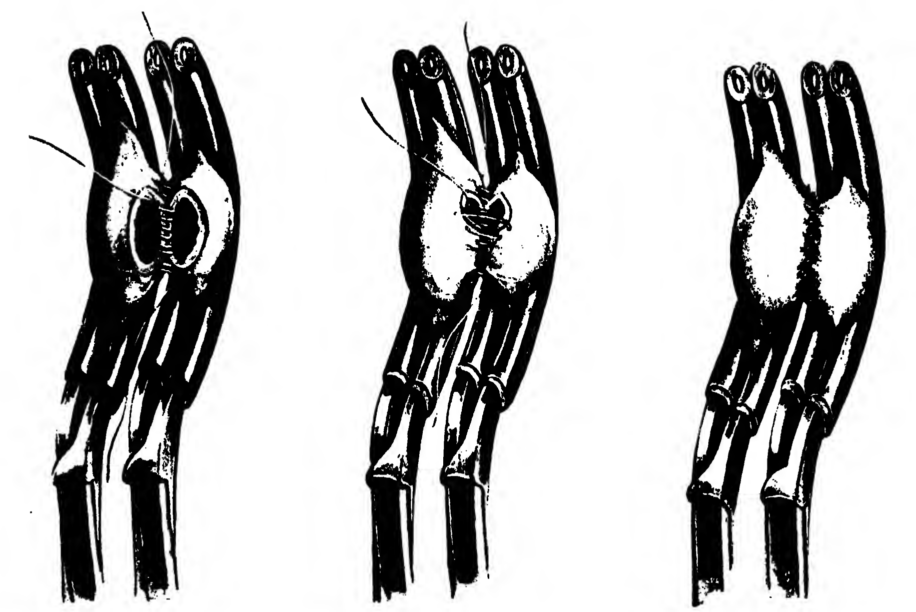
A B C

Fig. 58. Cholecystenterostomy.
A, First stage; B, Second stage; C, Third stage.

laid aside still threaded, to use later: this picks up the serous and subserous coats only. An incision is now made into the gall-bladder and into the duodenum parallel with the first line of suture, but about $\frac{1}{3}$ inch in front of it and about $\frac{3}{4}$ inch in length. Small tenaculum forceps (see Fig. 58, C) are now inserted into each end of the visceral incision, one blade being in the gall-bladder and one in the duodenum, thus putting the incision on the stretch and bringing the edges into apposition. A fine chromic catgut suture is then used to join the

two margins of the visceral incision, embracing all the coats and securing the apposition of the mucous surfaces of the duodenum and gall-bladder. This is continued round the whole circle of the aperture that is to be the anastomotic opening, and when it reaches the point whence it started it is knotted and cut short. The serous suture previously laid aside is then picked up and continued around outside the marginal suture, until the circle is completed, when it is also knotted and cut short.

Thus is completed the union of the viscera, and after removing the clamps and wiping gently with a swab wet with normal saline solution,



D E F

FIG. 59. CHOLECYSTENTEROSTOMY.
D, Fourth stage; E, Fifth stage; F, Final stage.

the omentum is arranged around the junction and the abdominal wound is closed as described on p. 110. If clamps have been used and due care has been observed, drainage of the right kidney pouch is unnecessary.

This is the method I have employed for some years and which I can recommend after considerable experience.

I employed union by suture in my first cases, then I used the decalcified bone bobbin for a time as a splint over which to apply the sutures, and afterwards a Murphy button, but after one experience of having the button retained and another of having the opening close within a few months after the employment of a button, I returned to the method by simple suture.

Modifications. If the gall-bladder duodenal junction (see Fig. 60) appears to be impracticable on account of adhesions or from other reasons, it has been suggested that an anastomosis may be made between the stomach and gall-bladder.

Terrier, in 1902, collected seven cases which appeared to show that bile in the stomach is not injurious; it is, however, certainly undesirable, and this modification should not be performed when other methods are available. Nor can I recommend union to the colon (see Fig. 61), which is the simplest of all these anastomoses, except in those cases where a rapid anastomosis is very desirable in patients extremely ill, as in obstruction from cancer of the head of the pancreas. Although union to the colon has usually been successful—in fact one of my earliest cases was to the colon and the patient was in good health many years later—yet I do not recommend it from the fact that I know of one case under the care of a colleague and have heard of others in which septic infection produced suppurative cholangitis and abscess in the liver. If, therefore, the duodenum be not available, I strongly recommend the commencement of the jejunum being found and a point about 18 inches from the duodeno-jejunal junction being brought up and united to the gall-bladder as shown in Fig. 62; at the same time an entero-anastomosis may be made very quickly between the two arms of the jejunal loop (see Fig. 63). The use of the clamps and the methods of applying the sutures are similar to those described in uniting the gall-bladder to the duodenum.

If the patient be very ill and time a serious object, the latter part of the operation (entero-anastomosis) can be omitted.

Still another method has been suggested—dividing the jejunum and uniting the proximal end of the distal portion to the gall-bladder and the distal end of the upper portion into the jejunum at a lower level. I have had no experience of this, nor can I see that it has any advantages over the previous method.

Results. Cholecystenterostomy, though in itself a comparatively simple operation, is one practically only undertaken in serious conditions, such as complete obstruction of the biliary passages by growth of the common bile duct or head of the pancreas, or by interstitial pancreatitis.

When undertaken for the temporary relief of malignant disease the mortality is necessarily very considerable, probably not less than 50%, whereas when the jaundice for which the operation is undertaken is dependent on non-malignant conditions, though the patients as a rule are extremely ill, the mortality has only been 4% in my experience of over sixty cases.

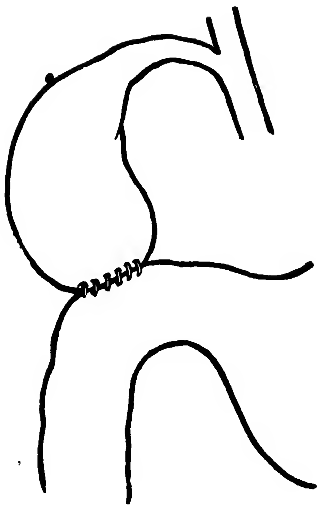


FIG. 60. UNION OF THE GALL-BLADDER TO THE FIRST PART OF THE DUODENUM.

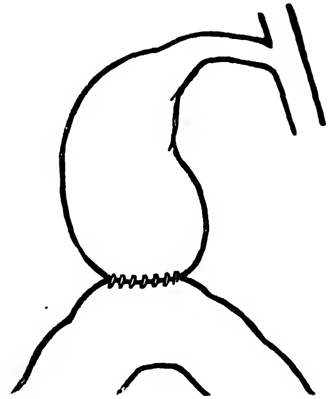


FIG. 62. UNION OF THE GALL-BLADDER TO THE JEJUNUM.

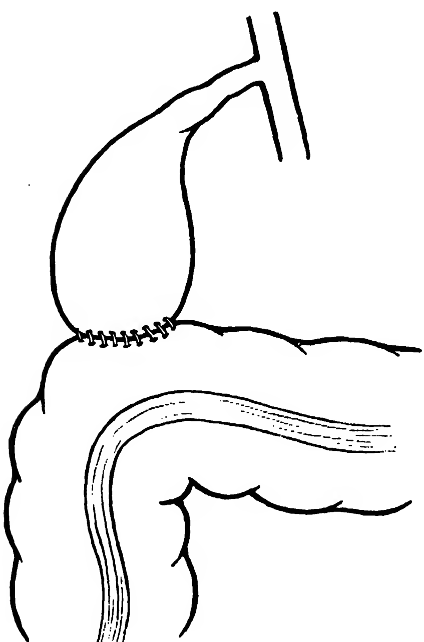


FIG. 61. UNION OF THE GALL-BLADDER TO THE COLON.

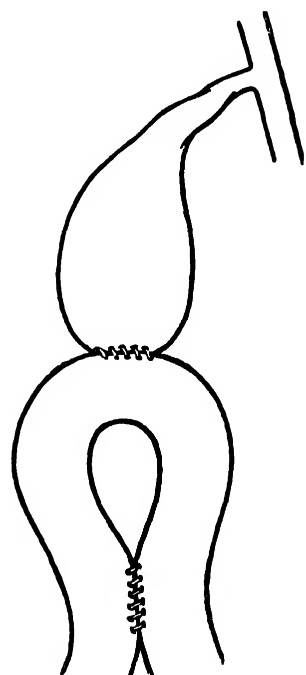


FIG. 63. UNION OF THE GALL-BLADDER TO THE JEJUNUM COMBINED WITH ENTERO-ANASTOMOSIS.

CHAPTER III

OPERATIONS UPON THE BILE DUCTS

CHOLEDOCHOTOMY

By choledochotomy is understood the operation of exposing and opening the common bile duct. It is usually required for the removal of gall-stones from the common duct, but through the incision concretions may also be removed from the hepatic duct.

It was first suggested by Langenbach in 1884, though Kummell (quoted by Fenger) stated in 1890 that he, several years before, had performed cholecystectomy on a female patient of forty, after which he had removed a stone the size of a walnut from the common duct through an incision which he afterwards sutured. The operation was a very prolonged one and the woman died twenty-four hours afterwards.

Courvoisier performed the first successful operation on January 22, 1890, and two more, both successful, in February and March of the same year.

Since that time it has been done by many surgeons, and at the present time it may be confidently asserted that there is no portion of the gall-bladder and common, cystic, or primary divisions of the hepatic duct, which cannot, under ordinary circumstances, be reached for the removal of calculi.

Operation. The bile ducts are fully exposed as described on p. 109. When the liver is lifted or rotated and the hepatic region elevated mechanically, the surgeon with his left forefinger and thumb can so manipulate the common duct as to render prominent any concretions, which can then be directly cut down on, the edges of the opening in the duct being caught by pressure-forceps. The assistant can now take hold of the forceps with his left hand, as they will form a sufficient retractor, since the duct is so near the surface.

When the duct is incised there is usually a free flow of bile, which, it must be remembered, is probably infective, but by protecting the edges of the wound by sterile gauze and by packing swabs into the kidney pouch and over the viscera on the left side and below, and rapidly mopping up the bile as it flows, by means of sterilized gauze pads, any soiling of the surrounding parts is avoided. If thought necessary, the

bulk of the infected bile can be drawn off by the aspirator either from the gall-bladder or from the common duct above the obstruction before the incision into the bile passage is made.

The edges of the wound are protected by being covered with a long sterile gauze swab which may be held in position by temporary sutures or forceps.

After removing all obvious concretions by means of the scoop, the fingers are passed behind the duodenum and along the course of the hepatic ducts to feel if other gall-stones are hidden there, and a gall-stone scoop, the only special instrument I use, is passed into the primary division of the hepatic duct in the liver and down to the duodenal orifice of the common duct; and to ensure the opening into the duodenum being patent, a long probe is passed into the bowel. As the duct is usually dilated, it is easy to insert the finger through the incision in the duct and to thoroughly explore the whole of the common duct to see that no concretions have been overlooked.

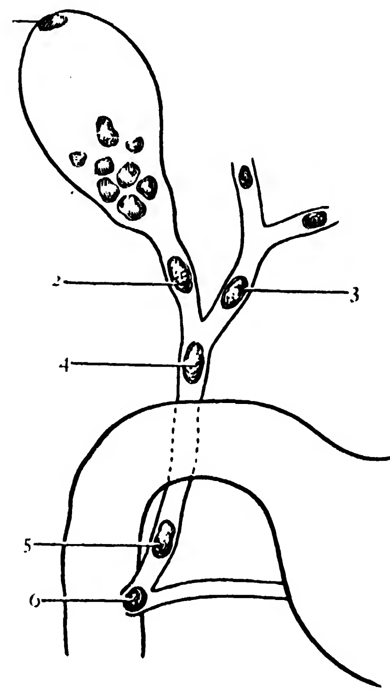


FIG. 64. DIAGRAM TO SHOW THE POSITION OF CALCULI IN THE BILIARY PASSAGES AND THE POINTS AT WHICH THEY MAY BE REACHED FOR REMOVAL. 1, Site of incision for cholecystotomy; 2, Site of incision for a gall-stone impacted in the cystic duct; 3, Site of incision for a gall-stone impacted in the hepatic duct; 4, Ordinary site of incision for choledochotomy; 5, Site of incision for transduodenal choledochotomy; 6, Ordinary site of incision for duodeno-choledochotomy.

As the bile is practically always infected in common duct cholelithiasis, drainage of the bile passages should always be carried out, preferably through a cholecystotomy, but where that is impracticable it is advisable to drain the common duct through a tube inserted into the incision through which the gall-stones have been removed.

The incision into the bile duct (when the gall-bladder is available for drainage) is closed by an ordinary curved, round needle held in the fingers without any needle-holder, a continuous catgut suture being used for the margins of the duct proper, and a continuous fine green chromic catgut suture being employed to close the edges of the peritoneum over the duct (see Fig. 66).

When the gall-bladder is contracted and not available for drainage, especially if the pancreas is indurated and swollen from chronic pancreatitis and likely to exert pressure for a time on the common duct, I insert a firm drainage tube (preferably a No. 12 Jaques's catheter)

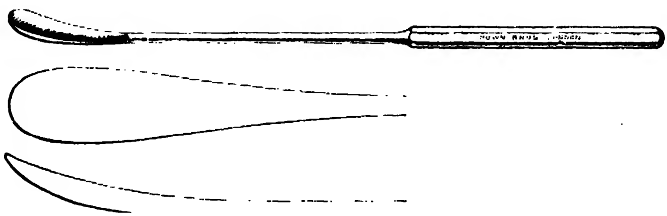


FIG. 65. AUTHOR'S GALL-STONE SCOOP.

directly into the duct, passing it upwards into the hepatic duct, and closing the opening around it by a purse-string suture, the tube being fixed into the opening by a catgut stitch which will hold for about a week (see Fig. 67). Where, however, the size of the gall-bladder will

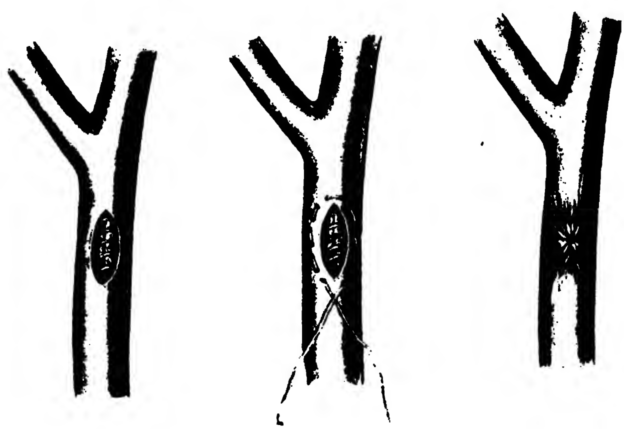


FIG. 66. DIAGRAM TO SHOW THE METHOD OF INCISION AND SUTURE OF THE COMMON BILE DUCT.

permit of it, I prefer to suture the opening in the duct and to fix a drainage tube into the fundus of the gall-bladder, as this drains away all infected bile and avoids pressure on the newly sutured opening in the duct.

Although there is seldom any fear of leakage, yet, where the ducts have been incised and extensive adhesions separated, there is usually some tendency to pouring out of fluid in the first few hours. I therefore generally insert a gauze drain through a drainage tube passed into the

right kidney pouch, bringing it out through a stab puncture 3 or 4 inches to the right of the chief incision; and through the same stab puncture the tube draining the common duct or gall-bladder is also passed. Dependent drainage is thus obtained and the anterior incision can be securely closed. This drain is usually removed within forty-eight hours.

When the patient is thin, by adopting the methods I have suggested the common duct is actually level with the surface; and even in a stout patient the common duct is made easy of access, so that the operation may generally be completed in from thirty to forty minutes where adhesions do not give unusual trouble.

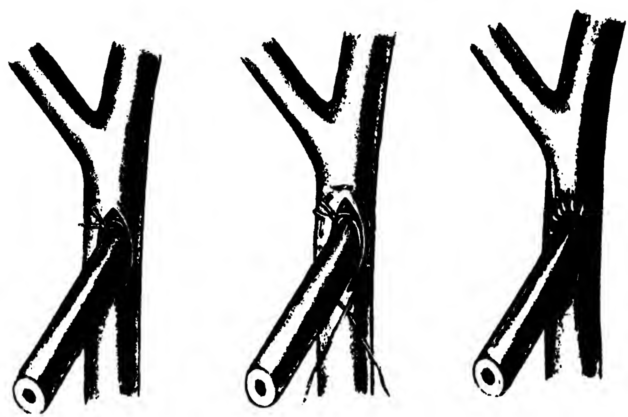


FIG. 67. DIAGRAM TO SHOW THE METHOD OF DRAINING THE COMMON BILE DUCT.

It is of the utmost importance that the ducts should be cleared of all concretions or the operation will be futile, as shown by Kehr, who stated that he had left concretions behind in 16·6 % of his cases, and by Riedel, Fenger, Lauenstein, Küster, and others. It is important, therefore, after the ducts have apparently been cleared by the scoop, that a finger should be introduced through the incision into the common duct in order that it may be made quite clear that no concretions remain. If for any reason this is not convenient, a careful palpation of the outside of the duct at the time that the probe has been passed into the duodenum and is still in position, will enable the duct to be thoroughly palpated from the outside.

Where there are numerous floating gall-stones in the common duct it is most important that the scoop should be passed into both primary hepatic ducts, as on several occasions I have brought down calculi which otherwise it would have been impossible to discover.

Should there be any difficulty in closing the common duct after choledochotomy owing to the grave condition of the patient or from anæsthetic difficulties, it may be borne in mind that a simple drainage of the right kidney pouch through a dependent opening has occasionally answered all requirements; but this method is not to be recommended as the rule, as it is fraught with danger of general infection of the peritoneum.

Results. Choledochotomy, which has frequently to be performed under such unfavourable conditions as the presence of deep jaundice, infective or suppurative cholangitis, and other complications associated with the presence of gall-stones in the common duct, must always be an operation attended with danger, especially in the hands of inexperienced operators; though since the introduction of improved methods the mortality has been considerably reduced. Although I have had a series of fifty-three choledochotomies without a death, the total mortality of my cases since 1899 has been 5·1%. It should not exceed 5%, and in the 1907 *Report of the Rochester Clinic* out of fifty-two cases there was only one death, a mortality of 1·9%.

The division of choledochotomies into complicated and uncomplicated is open to serious objection, as practically all cases of common duct cholelithiasis have some complication, hence my statistics are based on every case in which the operation has been performed.

MODIFICATIONS OF CHOLEDOCHOTOMY

Various modifications of the ordinary operation of choledochotomy may have to be practised under certain conditions; for instance, if the patient be extremely ill and the adhesions are such that their separation would involve a great expenditure of time with consequent shock to the patient, it may sometimes be possible to make the right side of the common duct prominent by passing the fingers of the left hand above the stomach and pressing the duct outwards at the same time that the thumb presses inwards the tissues superficial to the duct, thus rotating the parts within the grasp of the hand and rendering prominent the common duct.

A gall-stone in the common duct will now be made prominent and can be readily cut down on and removed; the duct being afterwards explored and drained as described in the ordinary operation of choledochotomy. In a case of this nature it will probably be desirable to spend very little time over suturing the duct, and as the adhesions will assist in preventing extravasation of bile, the surgeon may be content to trust to drainage of the right kidney pouch by passing a large drainage tube through a stab wound at the most dependent part. If, however, time permits, the tube may be fixed in by suture and the duct closed around it.

DUODENO-CHOLEDOCHOTOMY

If a gall-stone be impacted in the pancreatic portion of the common duct or in the ampulla of Vater and it is found impracticable to press it onwards into the duodenum or upwards into the first part of the duct, the removal of the gall-stone may be effected through the opened duodenum. The operation is known as duodeno-choledochotomy if the stone is extracted through the papilla either by dilating or incising it, or as

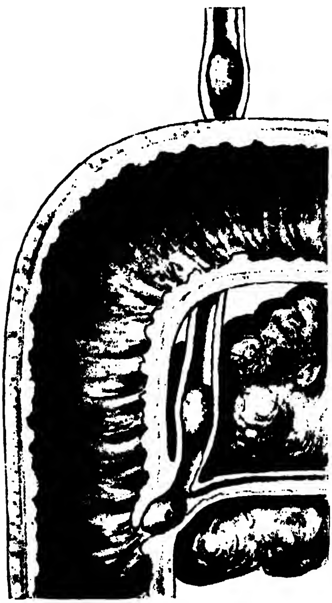


FIG. 68. DIAGRAM SHOWING GALL-STONES IN THE SUPRADUODENAL AND PANCREATIC PORTIONS OF THE COMMON DUCT AND ALSO IN THE AMPULLA OF VATER.

FIG. 69. DUODENO-CHOLEDOCHOTOMY. McBurney's operation.

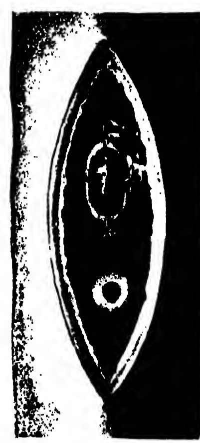


FIG. 70. TRANSDUODENAL CHOLEDOCHOTOMY. Kocher's operation.

transduodenal choledochotomy if the pancreatic portion of the common bile duct has to be incised through the posterior wall of the duodenum. To the former operation McBurney's name is attached, to the latter Kocher's.

The operation through the duodenum is much simplified by mobilizing the duodenum (Kocher), which is effected by dividing the peritoneum vertically as it passes outwards from the duodenum over the front of the right kidney and by stripping the peritoneum inwards from the kidney until the duodenum is reached. The duodenum and the head of the

pancreas are thus rendered so mobile that they may be lifted forward and easily manipulated.

The duodenum having been mobilized is drawn forwards and held at the surface of the wound by the left thumb and forefinger. Gauze swabs are now packed around it so as to avoid soiling of the wound when the intestine is opened. A vertical incision of about an inch is made through the front wall of the second part of the duodenum, which exposes the papilla on the posterior wall, the termination of the common bile duct being rendered more distinct by the bulging gall-stone. Bile or intestinal fluid is carefully mopped up. If a concretion is impacted in the ampulla of Vater it will necessarily be small, and can be readily removed after dilating the orifice by introducing the blades of a pair of dressing forceps closed and afterwards expanding them, or the papilla may be incised over a director or by cutting down directly on to the concretion. Through the widely open papilla a gall-stone scoop can be passed up the duct so as to clear out any other gall-stones or débris that may be present.

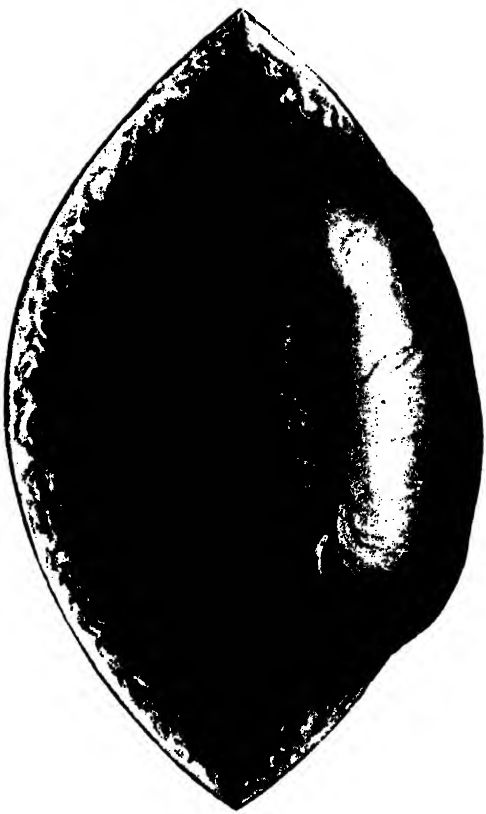


Fig. 71. Drawing to show Mobilization of the Duodenum.

Rarely it is possible, when the papilla is exposed, to squeeze the gall-stone into the duodenum without incising or dilating the papilla. This I have found practicable on two occasions (see Fig. 72).

If the impacted stone be large it may be impacted in the pancreatic portion of the common duct, in which case the entire thickness of the posterior wall of the duodenum may require to be incised, and possibly an intervening condensed portion of the head of the pancreas, which in this condition is usually fibrous from past interstitial inflammation.

The incision may be made on to the bulging concretion sufficiently

long to permit of the extraction of the gall-stone. The edges of the wound in the common bile duct and of the incision through the posterior wall of the duodenum are caught up together by small volsellae or nibbed forceps, and one or two sutures of catgut are applied on either side and at the upper and lower angles of the wound in the duct, so as to avoid any danger of extravasation of bile or intestinal contents into the retro-peritoneal tissues should they have been accidentally opened up, an accident that actually did occur in one case that I know of. After the application of the sutures the duct is explored by a gall-stone scoop or by the finger in order to ascertain that all concretions have been removed.

FIG. 72. GALL-STONE IMPACTED AT DUODENAL PAPILLA. Drawing of Specimen No. 2826, R. C. S. Museum.

When the papilla and adjoining part of the termination of the bile duct are incised I have not thought it necessary to apply sutures in any of my cases. If at the same time that duodeno-choledochotomy has been performed, the first portion of the duct has been opened, it may be advisable, as was first suggested by Kehr, to insert a strip of gauze into the upper opening and by means of long slender forceps to drag it downwards through the papilla, thus sweeping the lower part of the common duct clear of all débris.

RETRODUODENAL CHOLEDOCHOTOMY

This operation was described by Haasler in 1898 for reaching a calculus impacted in the pancreatic portion of the common duct.

As, in an experience of nearly 200 cases of choledochotomy, I have yet to meet with a case in which I could not move the calculus backwards to the first portion of the duct, whence it could be removed, or reach it from below after laying open the papilla, I cannot see the necessity of this modification of the operation of choledochotomy.

Should it be thought necessary to perform the operation, the duodenum must be mobilized by incising the peritoneum an inch or more external to the second part of the bowel, and after reflecting the serous membrane inwards the duodenum may be turned over, exposing the posterior surface

of the head of the pancreas and the pancreatic portion of the common duct, which in 62 % of cases passes through the substance of the pancreas. The pancreatic portion of the common duct is then incised, and if needful the portion of pancreas overlying it may be safely cut through, as it is usually fibrosed from the irritation of the concretion having set up interstitial pancreatitis.

After the stone has been removed and the duct cleared, the edges of the incision into it must be closed by catgut sutures and the duodenum replaced. Drainage of the retroperitoneal operation area is of vital importance, as extravasation of bile may occur, since the duct in this situation has no peritoneal cover.

CHOLEDOCHOSTOMY

Choledochostomy is the term applied to the direct surface drainage of a dilated common bile duct, an operation frequently performed as part of the technique of choledochotomy, in which class of cases it is very successful. The name is, however, usually reserved for a more serious class of cases in which the common duct has become cystic.

In certain cases the common bile duct becomes dilated into a large cyst capable of holding even up to several pints of fluid, and this may or may not be associated with a considerable dilatation of the gall-bladder.

In one of my cases the condition gave rise to the suspicion of a pancreatic cyst associated with a distended gall-bladder, a mistake in diagnosis which happens to have been frequently made in such cases. The cause of the condition is somewhat obscure, it being more frequently due to a kink in the common duct than to obstruction from a gall-stone or a stricture. Simple drainage of such a cyst is known as choledochostomy, an operation seldom completely successful, since it is apt to be followed by a biliary fistula or to prove fatal from sepsis or exhaustion.

The technique of the operation differs in no way from that described under simple cholecystotomy. The cyst is first emptied by an aspirator, then explored to remove any cause of obstruction if a removable one be found. Through the opening in the cyst a drainage tube is inserted and sutured in position. The edges of the opening in the cyst are then sutured to the aponeurosis by three or four catgut sutures, the operation being completed as described on p. 119.

Choledochostomy, if performed on a common bile duct only moderately distended, for some obstruction in the lower part of the duct or in the head of the pancreas, which it is impossible to remove, is equally unsatisfactory, as the permanent biliary fistula resulting is no less distress-

ing than dangerous ; since, even if septic complications do not supervene, the alternative issue is a steady loss of flesh and strength until some intercurrent ailment brings on a fatal ending.

This operation is, therefore, to be avoided, if it be in any way possible to remove the obstruction or to short-circuit it by the operation next to be described.

FIG. 73. ENORMOUS DILATATION OF COMMON BILE DUCT.
Drawing of Specimen No. 1419, Guy's Museum.

In a case of my own, although the patient recovered after a choledochostomy, a biliary fistula resulted and choledochenterostomy had to be performed before a cure was effected.

Specimen No. 1419, Guy's Museum (see Fig. 73), shows a dilatation of the common bile duct. There is a thick-walled cyst 6 inches across, representing the common bile duct ; the portion of duct below this

is of less than the normal calibre, and has a valvular fold, which completely obstructs the lumen. The tumour was aspirated twice, $3\frac{1}{2}$ pints of bile being withdrawn on each occasion without relief. Then choledochostomy was performed and death ensued two days after.

CHOLEDOCHENTEROSTOMY

This operation, which has for its purpose the short-circuiting of an irremovable obstruction in the lower end of the common duct, consists in uniting the common bile duct to some portion of the intestine, preferably the duodenum.

For this purpose the duodenum may be mobilized by dividing the peritoneum vertically an inch or more external to its reflection from the bowel on to the front of the right kidney. By stripping the peritoneum the duodenum is reached, and it can then be easily drawn forwards and if needful upwards, and made to reach the supraduodenal portion of the common duct.

If the common duct be hugely dilated, as in the cystic condition previously described, there is no difficulty in bringing it down to meet the duodenum.

The curved clamp-forceps shown in Fig. 57 can now be applied to the duodenum, and, if the common duct is largely dilated, a clamp can also be placed on that portion of the duct selected for the anastomosis. The two portions to be anastomosed can now be placed in apposition, and an opening of $\frac{3}{4}$ inch must be made into the viscera to be anastomosed, the union being made by two continuous sutures, one serous suture of Pagenstecher's thread being used for the peritoneal surfaces, another of fine chromic catgut being employed to take up and join the whole thickness of the margins of the two visceral incisions; the anastomosis being carried out in the manner described under cholecystenterostomy (see Figs. 58 and 59, p. 138).

If, on account of adhesions or for other reasons, the duodenum cannot be utilized for the anastomosis, a loop of jejunum about 20 inches from the duodeno-jejunal flexure may be brought up and used to make the intestinal anastomosis; but in this case it will be advisable to make, in addition, an entero-anastomosis as shown in Fig. 63, p. 141, so as to avoid the chance of intestinal obstruction from kinking of the jejunal loop.

A case on which I operated, and which is fully described in my work, *Diseases of the Gall-bladder and Bile Ducts*, illustrates the failure of choledochostomy and the complete success of choledochenterostomy.

CYSTODOCHENTEROSTOMY

Cystodochenterostomy is the name applied to the operation of uniting the cystic duct to the intestine. It can be performed without serious difficulty when the cystic duct is dilated, and is even feasible with a duct of normal calibre (see Fig. 56, p. 136). It has for its purpose the short-circuiting of an obstruction in the common duct when the gall-bladder has been destroyed by disease or cholecystectomy has rendered cholecystenterostomy impossible.

In some cases it may be performed to save surface drainage of the duct after removal of the gall-bladder, and in such cases, when long-continued drainage is required, as in interstitial pancreatitis causing obstruction, the operation is a very useful one.

The union of the duct to the duodenum may be effected by means of the decalcified bone bobbin or by simple suture. I have employed each of these methods, but I prefer now to use a double continuous suture, as described under cholecystenterostomy.

If needful, the duodenum may be mobilized, as it makes the operation easier, but if the cystic duct be cut across near the gall-bladder there will be sufficient length of duct to enable the anastomosis to be made without interfering with the peritoneal attachment of the bowel.

CHOLEDOCHECTOMY

A portion of the common duct may require to be removed for new growth or for stricture or for serious damage from gall-stone obstruction.

In one case Doyen excised the damaged portion of the duct and completed the operation by joining the two ends of the duct completely without drainage.

In another case Kehr excised a stricture of the common duct, joined the upper to the lower portion along the posterior margin, and drained the part left unjoined at the front.

Halsted, Mayo, and Moynihan have excised tumours of the common duct and have subsequently united the open ends of the duct by suture, leaving the anterior part open for drainage, or have ligatured both ends of the cut duct and then anastomosed the gall-bladder to the duodenum so as to make a new passage for the bile.

For stricture or injury due to gall-stones this operation may be both immediately successful and ultimately lead to perfect recovery.

For malignant growth in the common duct the occasion can be only rare in which the growth is caught at a sufficiently early stage to render the operation worthy of being attempted. In the cases that have been reported the relief has been of a temporary character, but so marked as to have made the operation worth doing.

PLASTIC OPERATION UPON THE BILE DUCTS

In a case of stricture of the cystic duct in which I did not think it desirable to excise the gall-bladder, I laid open the stricture and united the margins of the vertical incision transversely after the principle

FIG. 74. PLASTIC OPERATION FOR STRICTURE OF THE BILE DUCT.

suggested by Mikulicz in pyloroplasty, and in a case of stricture of the common bile duct Mr. Moynihan performed a similar plastic operation.

Kehr repaired a rent with loss of substance in the common duct by turning up a sero-muscular flap from the pyloric end of the stomach.

OPERATIONS UPON THE HEPATIC DUCT

Hepaticotomy. The hepatic duct is frequently drained as part of the operation of choledochotomy, the tube being introduced through the incision of the common duct and passed upwards into the hepatic duct.

Gall-stones are also frequently removed from the hepatic duct through an incision in the common duct, this being effected either by 'milking' the stones downwards to the choledochotomy opening or more frequently by bringing them down by means of the gall-stone scoop. When the common duct is dilated, the hepatic duct practically always participates in the dilatation, and when a choledochotomy opening is made, it is as a rule easy to insert the finger and pass it up to the primary division of the hepatic duct ; but by means of the scoop both primary divisions of the hepatic duct can also be explored.

This procedure is of vital importance in all cases of common duct cholelithiasis, as on many occasions when there was every appearance of the ducts having been cleared I have found one or more gall-stones hidden in the upper reaches of the hepatic ducts and have been able

to remove them. Some of these cases have been reported in my work on *Diseases of the Gall-bladder and Bile Ducts*, 3rd edit., and others I have not yet reported.

But besides these floating stones it occasionally happens that a large calculus becomes impacted in the hepatic duct, and it is then necessary to incise it vertically over the concretion in the same way that the common duct is opened, and after extracting the concretion the duct may be drained or sutured.

This operation I have performed successfully, and it has also been done by other surgeons.

Case 508 in my work *Diseases of the Gall-bladder and Bile Ducts* is a description of such a case, in which an impacted stone in the hepatic duct had led to a biliary pulmonary fistula and was cured by hepaticotomy.

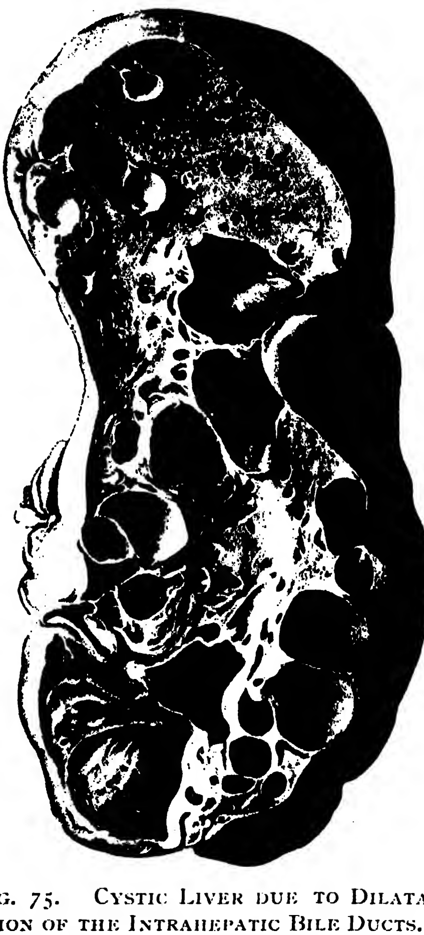


FIG. 75. CYSTIC LIVER DUE TO DILATATION OF THE INTRAHEPATIC BILE DUCTS.

Hepatico-lithotripsy. If there is any difficulty in exposing the duct sufficiently to incise it with safety, it may occasionally be possible to crush an impacted calculus in the hepatic duct and to extract the fragments through an incision in the common duct; this operation I have performed with success, but I must confess to a preference for a clean incision and the removal of the concretion where that is possible.

Hepaticostomy. Just as the common bile duct may become enormously dilated apart from the cystic duct, so the hepatic duct outside the liver may be sufficiently dilated to form a distinct tumour, which may be treated by drainage as in a case operated on by Knowsley Thornton in 1888.

A case was described by Leonard Rogers in the *British Medical Journal*, 1903, vol. ii, p. 706, in which a dilated hepatic duct was incised and

drained under the impression that it was a dilated gall-bladder. The true condition was shown at autopsy to be caused by an impacted gall-stone.

As shown by a case of Nicolaysen's, such a dilatation of the hepatic duct may occur apart from gall-stone obstruction. In the case of hepaticostomy described by him and proved post mortem, no obvious obstruction was found and he considered the case a congenital deformity.

Transhepatic-hepaticostomy. When it is remembered that gall-stones may form in any part of the biliary apparatus within or outside the liver, it is not surprising that occasionally the ducts within the liver may become obstructed and lead to the formation of a dilated intra-hepatic duct.

I operated on such a case in February, 1891, the patient being a woman, aged 42, who was jaundiced and had suffered from symptoms of gall-stone obstruction. On opening the abdomen, a cyst of the liver was discovered and incised, nearly half a pint of bile-stained mucus and three gall-stones being removed. The cyst was packed with gauze to arrest bleeding and stitched to the surface. The patient recovered.

A case of H. V. Chapman's is recorded (*Abdominal Operations*, B. G. A. Moynihan) in which 480 c.c. of bile-stained fluid and 127 calculi were removed from such a cyst.

Hepato-duodenostomy. In certain cases of obstruction of the common duct from stricture or from actual loss of substance due to operation, in which the cystic duct or gall-bladder is not available for making the anastomosis, it may be desirable to unite the hepatic duct to the duodenum, an operation of considerable difficulty.

In the *Annals of Surgery* for August, 1905, p. 90, is a case reported by Dr. W. J. Mayo, in which, twelve months after a choledochotomy and cholecystectomy, an operation was undertaken for a biliary fistula and the hepatic duct was fixed to the duodenum.

The following description, together with the illustrations, is taken from Dr. Mayo's report :—

'A five-inch incision was made just internal to and parallel with the cicatrix of the former wound. A dense tangle of adhesions was encountered, involving transverse colon, duodenum, and stomach, on the one side, and the liver and ducts on the other. By following the remains of the fistulous track carefully and keeping close to the liver, the original drainage opening at the site of the cystic duct was discovered. The hepatic duct was dilated and easily admitted the tip of the index-finger to the primary division. The common duct was reduced by cicatricial contraction to a fibrous cord, along which could be traced a little stain of bile. During the separation of adhesions, it was noted that the duodenum overlapped the remains of the common duct and formed one wall of the fistulous track in its deeper portion. The external incision

was continued to the sternal notch and the overlying liver held upwards.

Fig. 76. Hepato-duodenostomy. Duodenum sutured to the tissues near the duct. (*Mayo.*)

Fig. 77. Hepato-duodenostomy. Suture of the duct to the duodenum. (*Mayo.*)

The duodenum was still further mobilized. The hepatic duct was freed from its attachment to the fistulous track and from the remains of the common duct; the adhesions posteriorly were not otherwise disturbed, and served a very useful purpose. About 3 inches from the pylorus the duodenum was caught with three catgut sutures and fastened firmly to the adhesions and scar tissue about the hepatic duct, so that it was brought into contact with the end of the piece of all the coats of the hepatic duct. At the point of easy contact, an elliptical piece of all the coats of the duodenum was excised of about the same diameter as the open end of the hepatic duct, and four or five catgut sutures were introduced from the mucous side through all the coats of both duct and intestinal wall. In this way the posterior line of the anastomosis was completed. By alternately placing a suture externally and internally the sides were built up in a similar manner to a two-row intestinal anastomosis, excepting that only the inner row penetrated the duct-wall. At the upper part

Fig. 78. Hepato-duodenostomy. (*Mayo.*)

the few remaining sutures were all placed before they were tied. The duodenum was still further attached laterally and anteriorly to the scar tissue covering the liver and ducts by catgut sutures, making a broad area of attachment. A drain of rolled gutta-percha tissue was placed at the upper angle of the abdominal incision and another at the lower, but each at a considerable distance from the anastomotic suture line. The abdominal incision was then closed. Time of operation, fifty minutes. Patient made an uninterrupted recovery. There was no leakage of any kind ; drains were removed on the sixth day ; patient discharged on the sixteenth day. Patient, re-examined ten months after the operation (March 22, 1905), had gained 31 pounds in weight and was in excellent health.'

LUMBAR OPERATIONS UPON THE BILE PASSAGES

Although cholecystotomy, cholecystectomy, and choledochotomy have all been performed through a lumbar incision with success, yet this route has usually been adopted only when a mistake in diagnosis has occurred, such as mistaking a dilated gall-bladder for a cystic kidney, or finding, when exposing a movable kidney, that the gall-bladder is distended owing to obstruction in the ducts and that it can be made to project into the lumbar wound without difficulty. As routine procedures lumbar operations on the bile passages cannot be advised.

UNION OF THE LIVER TO THE DUODENUM

This operation was first suggested and put into practice by Kehr, and has since been advocated by Maylard of Glasgow for cases of permanent obstructive jaundice incapable of relief otherwise. The theory on which it is based is that by opening one or more of the intrahepatic bile ducts and connecting the surface of the wounded liver to the opened duodenum, the obstruction to the flow of bile into the intestine will be short-circuited.

So far no success has attended the few operations that have been done, nor does it seem probable that the operation will be likely to afford sufficient relief to render it worth while undertaking so serious and dangerous a procedure.

CHAPTER IV

OPERATIONS UPON THE PANCREAS

ANATOMICAL CONSIDERATIONS

THE greater part of the pancreas lies in the epigastrium, but a portion of the body and the tail extend into the left hypochondrium, and the head may project into the umbilical region. The organ, a long, pinkish, cream-coloured gland, stretches transversely across the posterior abdo-

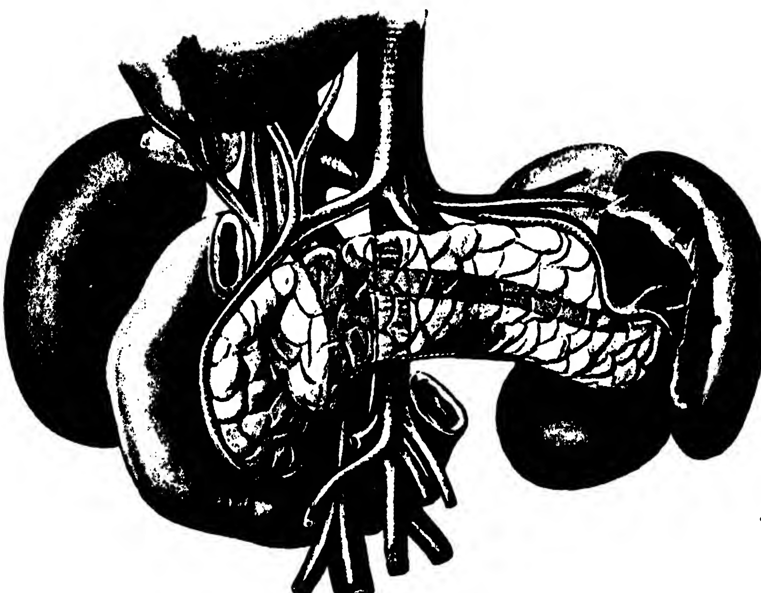


FIG. 79. TO SHOW THE RELATIONS OF THE PANCREAS AND ITS VASCULAR SUPPLY.

minal wall, from the concavity of the duodenum to the lower and inner border of the spleen.

The enlarged right extremity, or 'head', extends downwards and to the left, lying in the concavity of the duodenum in contact with its second and third parts, and opposite to the second and upper part of the third lumbar vertebra. The short and comparatively narrow portion of the gland termed the 'neck' arises from the upper and right part of the head. It runs upwards and to the left, and after a course of

about one inch merges into the 'body', which runs backwards and to the left at the level of the first lumbar vertebra. The pointed left extremity, or 'tail', is the least firmly attached portion of the organ. It merges so gradually into the body that no sharp line of distinction can be drawn between the two.

The disk-shaped head is separated from the neck by a deep groove, the 'incisura pancreatis'. In this groove lie the superior mesenteric vessels. That portion of the gland which lies to the left of the vessels, along the third part of the duodenum, is termed the 'uncinate process', and when, as happens occasionally, it is separated from the rest, it is

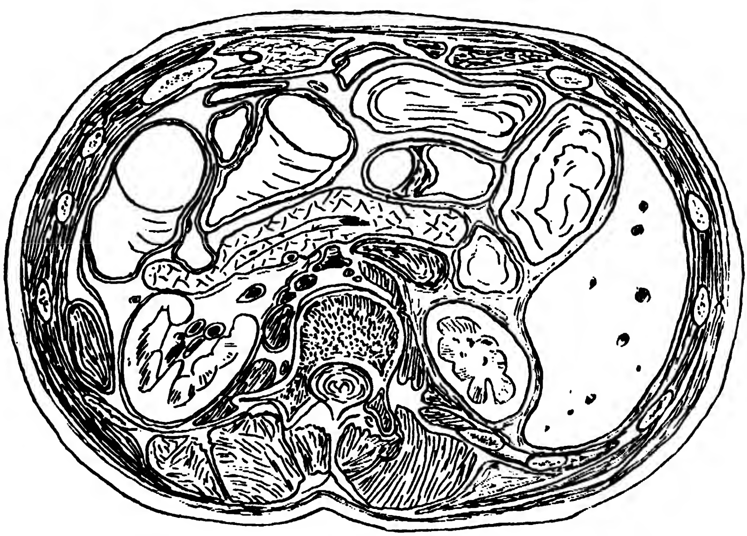


FIG. 80. TRANSVERSE SECTION OF THE ABDOMEN AT THE FIRST LUMBAR VERTEBRA. To show the relations of the pancreas. (*After Braune.*)

known as the 'lesser pancreas'. Above and to the right, the anterior aspect of the head is in contact with the commencement of the transverse colon. The lower part is covered by peritoneum, reflected from the lower surface of the colon and entering into the formation of the greater sac. The posterior surface of the head is devoid of peritoneum, and is directly applied to the front of the inferior vena cava, the left renal vein, and the aorta. The common bile duct also lies in a groove, or canal, in this surface.

The body runs from right to left, and slightly upwards. The anterior surface is separated from the stomach by the lesser sac of the peritoneum, the posterior wall of which is intimately attached to it. At the right extremity, where the body joins the neck, there is often a well-marked

prominence, the 'omental tuberosity', so called from its coming into contact with the small omentum when the stomach is distended. The posterior surface lies upon the aorta, the origin of the superior mesenteric artery, the pillars of the diaphragm, the splenic artery and vein (which run a tortuous course along its upper border in a single channel or maybe two separate grooves), the left kidney and renal vessels, and the left suprarenal capsule. This surface, like the posterior aspect of the head, is devoid of a peritoneal covering. At the full term of pregnancy the uterus rises and comes into contact with the lower border. The middle portion is covered by the jejunum. The whole surface is completely invested by peritoneum, derived from the descending layer of the transverse mesocolon.

The tail comes into contact with the lower part of the inner surface of the spleen.

Peritoneal relations. The transverse mesocolon is attached to a line running along the anterior border of the pancreas from the neck to the tail. The anterior layer passes upwards and backwards, over the superior surface, to form the posterior wall of the lesser sac, the posterior going downwards and backwards along the inferior surface to form the greater sac. At the neck, and on the head, the two sheets of peritoneum have separate lines of attachment, so that a somewhat variable area is devoid of a peritoneal covering and is only separated from the colon by areolar tissue. In many cases, however, the transverse mesocolon is continued as far as the hepatic flexure, so that the head and neck receive a complete peritoneal investment. The posterior surface is quite uncovered by peritoneum.

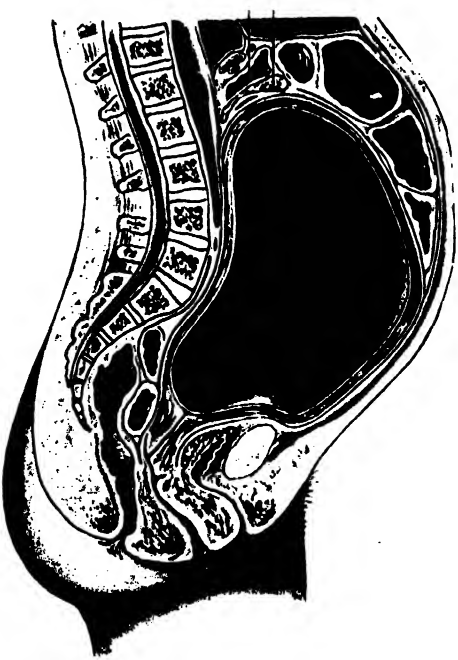


FIG. 81. VERTICAL SECTION OF THE BODY AT FULL TERM. Showing the relation of the uterus to the pancreas. A, Duodenum; B, Pancreas. (*After Braune.*)

The relations of the pancreas to the peritoneum are of the utmost importance, both from a surgical and pathological point of view. The

retroperitoneal position of the organ explains not only the course taken by pus in some cases of suppurative pancreatitis, upwards to the diaphragm and downwards towards the left iliac fossa, but also how such collections may be reached from the right or left loin, especially the latter, by an incision in the costo-spinal angle, or from the left iliac fossa, or between the ribs, when it has travelled upwards and presents as a subdiaphragmatic abscess.

The fact that the anterior surface of the pancreas projects into the lesser sac renders it easy to explain how this cavity is invaded in inflammatory affections or injury of the gland, and from its shape it is not

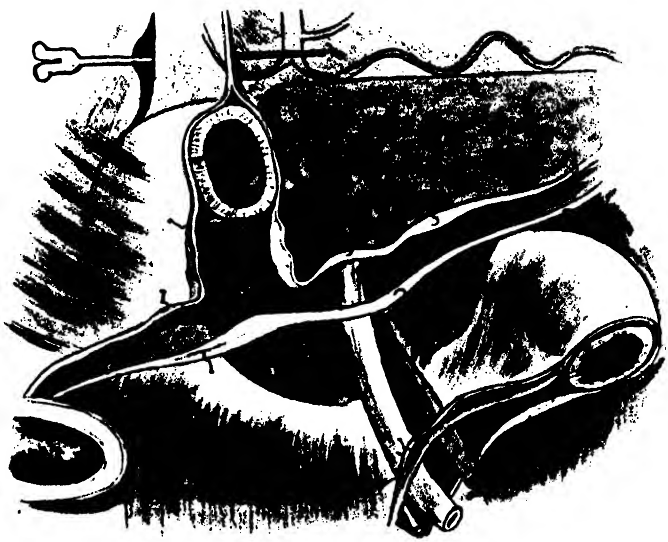


FIG. 82. DIAGRAM TO SHOW THE RELATIONS OF THE PERITONEAL REFLECTIONS OF THE PANCREAS.

difficult to see how, when it is filled with fluid, it is in many instances mistaken for a true pancreatic cyst. The real nature of this variety of pseudo-cyst was demonstrated many years ago by Jordan Lloyd.

Ducts. The pancreas has normally two ducts which open separately into the duodenum. The main duct, or *duct of Wirsung*, commences in the tail by the union of the small tributaries and courses through the body of the gland from left to right. In the neck it alters its course, bending downwards and backwards to reach the head of the organ. In the latter it lies nearer the posterior than the anterior surface, and comes into relation with the common bile duct, beside which it runs to the duodenum. The two ducts pierce the wall of the second part of the duodenum obliquely, about 3 to 4 inches below the pylorus, to open

into the lumen of the gut by a common orifice, situated on a papilla-like fold of the mucous membrane called the 'papilla or caruncula major'. Above this there is constantly found a small fold of mucous membrane,

FIG. 83. THE PANCREAS. Drawing of Specimen No. 277, R. C. S. Museum. Shows the separate lobules of the pancreas with their ducts opening into the duct of Wirsung.

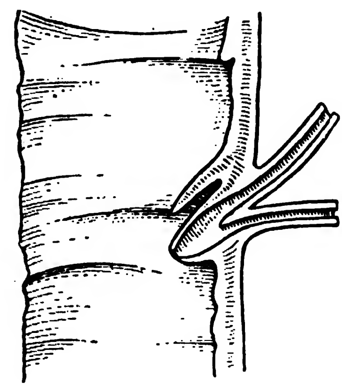


FIG. 84. AMPULLA OF VATER.

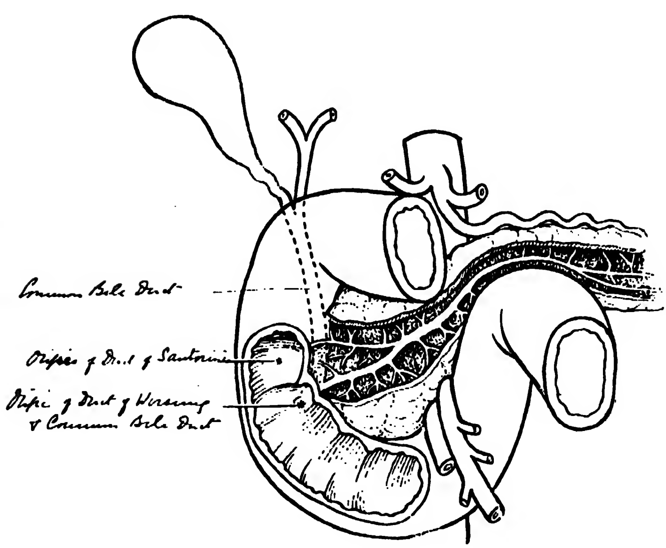


FIG. 85. THE EXCRETORY DUCTS OF THE PANCREAS.

which must be raised in order that the caruncle and its orifice may be seen, and running downwards from the caruncle is a small vertical fold known as the 'frenum carunculæ or plica longitudinalis'. Shortly before their termination the common bile duct and pancreatic duct

FIG. 86. OPENING OF THE AMPULLA OF VATER ON THE CARUNCULA MAJOR IN THE DUODENUM. (*After Testut.*)

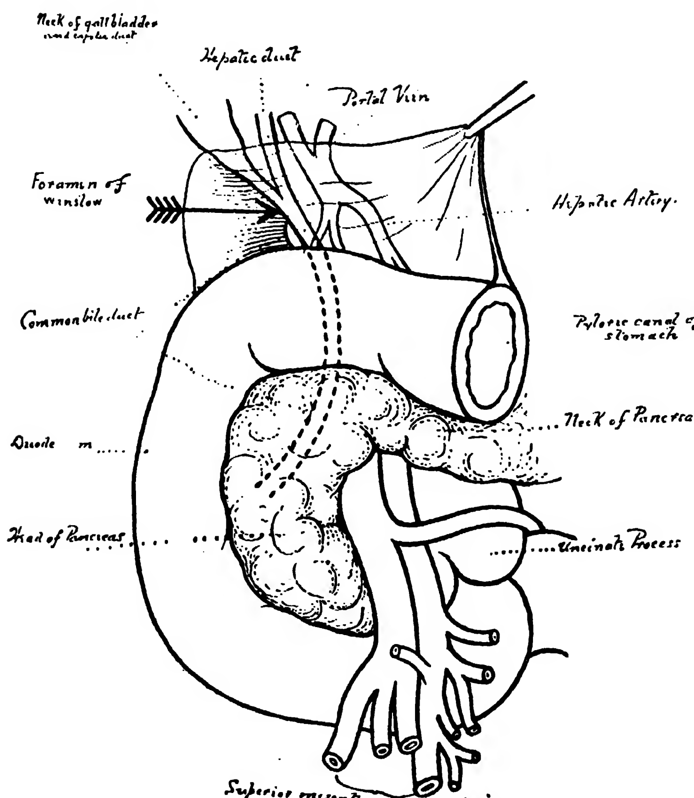


FIG. 87. HEAD OF THE PANCREAS SEEN FROM THE FRONT. (*After Testut.*)

usually unite to form a common channel, known as the 'ampulla or diverticulum of Vater'. This is a small oval or triangular cavity lying in the wall of the duodenum, having its apex at the duodenal orifice, and its base at the openings of the two ducts. The orifice of the common bile duct in the ampulla is above that of the pancreatic duct, and the two are separated by a small transverse fold of mucous membrane. The ampulla and the terminations of the two ducts are surrounded by a thin layer of unstriped muscle fibre, forming a sphincter (Oddi).

'IG. 88. ACCESSORY PANCREAS
E WALL OF THE DUODENUM.

The accessory duct, or *duct of Santorini*, is always present, although at times it is small or partly obliterated, especially in the neighbourhood of the intestine. The opening is situated on a small papilla, 'the papilla or caruncula minor,' lying 0·75 to 1 inch above the papilla major, on which the ampulla of Vater or the main duct opens. The duct of Santorini is morpho-

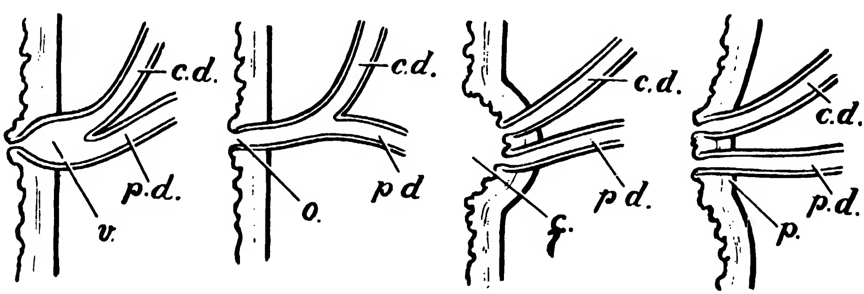


FIG. 89. DIAGRAM TO SHOW THE FOUR CHIEF VARIETIES IN THE TERMINATIONS OF THE BILE AND PANCREATIC DUCTS IN THE DUODENUM. *c.d.* Common duct; *f.*, Fossa; *o.*, Oval orifice; *p.*, Papilla; *p.d.*, Pancreatic duct; *v.*, Ampulla of Vater.

logically, and in some instances anatomically, the duct of the head of the pancreas. The relations of the common bile duct to the head of the pancreas have been described under the surgery of the biliary passages, p. 99, but it is necessary here to repeat the fact that in 62% of cases the common bile duct passes through the head of the pancreas, whereas in the remaining 38% it only lies in a deep groove on its posterior surface (see Fig. 87).

This is important from the fact that in 62% of cases of pancreatitis jaundice to a greater or less extent will be present on account of pressure on the common bile duct.

The varying terminations of the bile and pancreatic ducts in the duodenum have also been referred to and are shown in the diagrams in Fig. 89.

EXPLORATORY OPERATIONS

As the pancreas occupies a central position in the abdomen it may be reached either from the front or from either loin according to the part of the gland that is affected. Occasionally an exploration from the front may be completed by posterior drainage, but a primary exploration from behind is rarely practised.

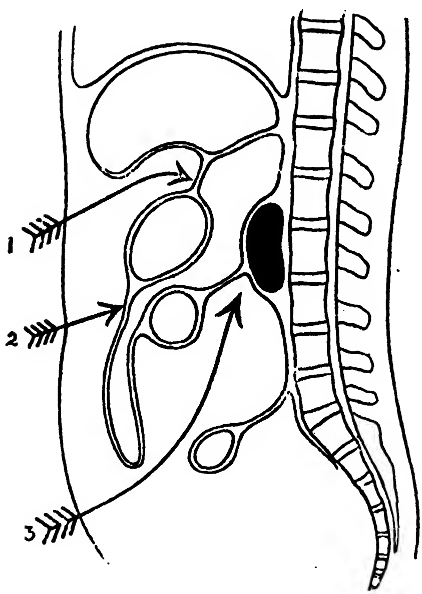


FIG. 90. THE PERITONEAL FOLDS IN RELATION TO THE PANCREAS. The arrows indicate three of the approaches to the gland.

The pancreas is more readily reached from the front by using the special table shown in Fig. 32, or by arching the spine forward by placing on the table a sand-bag or an air-cushion behind the back at the liver level.

Operation. The preparation of the patient and of the area of operation, as well as the after-treatment, are the same as those described on p. 112.

An incision is made about an inch to the right of the mid-line above the umbilicus, it being extended if needful upwards to the notch between the ensiform cartilage and the right costal margin or downwards below the umbilicus. The right rectus is either split or displaced outwards after dividing the anterior rectus sheath. On incising the posterior rectus sheath and the parietal peritoneum, the pancreas will be seen above the stomach through the gastro-hepatic omentum if the patient suffers from gastroptosis, otherwise it can only be seen after displacement of viscera.

Normally the pancreas may be approached—

(*a*) Above the stomach by incising the gastro-hepatic omentum (see Fig. 90, 1).

(*b*) Below the stomach, through the upper part of the great or gastro-colic omentum (see Fig. 90, 2).

(*c*) Through the transverse mesocolon by raising the transverse colon and great omentum (see Fig. 90, 3).

(*d*) The anterior part of the head of the gland may be reached by pushing the stomach upwards and inwards and dividing the peritoneum passing over the pancreas from the duodenum.

(*e*) The posterior part of the head of the pancreas may be exposed by mobilizing the duodenum (see Fig. 91).

(*f*) The tail of the gland may be reached by raising the stomach, pressing downwards and inwards the splenic flexure of the colon, and incising the reflection of the peritoneum passing from the colon to the parietes.

In incising the peritoneal reflections, if possible a bloodless spot is selected, but if a vessel in the lesser or great omentum or in the transverse mesocolon should be divided, it is immediately ligatured.

The chief dangers encountered in operating on the pancreas are hæmorrhage and the escape of pancreatic secretion. The former may be guarded against by avoiding as far as possible any obvious blood-vessels, and in case of their division applying a ligature of catgut, which must not be drawn too tightly lest it cut through the rather fragile tissues. The latter danger may be guarded against by avoiding injury to the main ducts, or in case of injury by their careful repair ; and in case of incision into the substance of the pancreas by carefully applying deep and superficial buried catgut sutures by means of a slender, round, half-curved needle and by suitable drainage : no dead spaces must be left and the sutures must not be drawn too tightly.

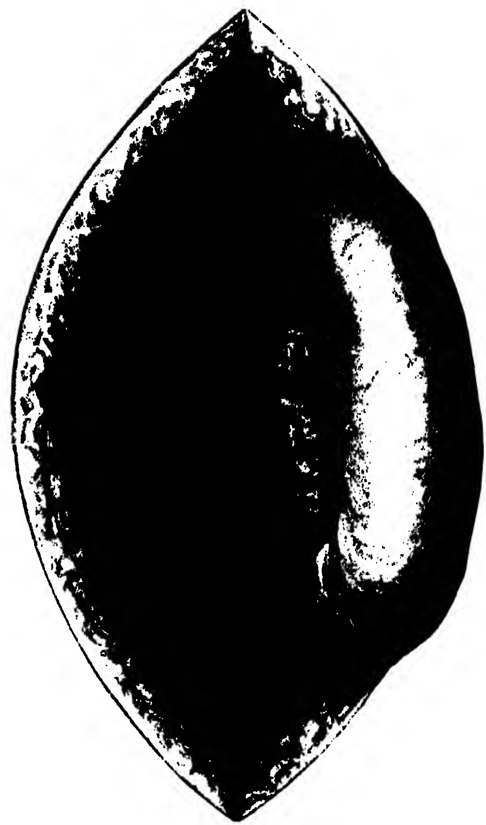


FIG. 91. MOBILIZATION OF THE DUODENUM TO EXPOSE THE POSTERIOR SURFACE OF THE PANCREAS. The surface exposed is the back of the head of the pancreas.

FIG. 92. LACERATION OF THE PANCREAS UNACCOMPANIED BY ANY OTHER INJURY. The accident was a crush between two vans, and on admission to hospital the patient only complained of slight pain in the epigastrium. Twenty-four hours later he became collapsed, but recovered. Subsequently he vomited, became seriously collapsed, and died three days after the receipt of the injury. At the autopsy a rupture of the pancreas dividing it into two nearly equal portions was found. There was fat necrosis in the neighbourhood, but no injury of the duodenum, liver, spleen, kidneys, or other abdominal viscera.

OPERATIONS FOR INJURY

Gunshot or stab wounds.

Operation must be undertaken as speedily as possible. All bleeding points must be taken up and ligatured, rents in other organs must be sought for and repaired, and any laceration of the pancreas must be carefully cleansed and sutured by deep and superficial sutures. If needful, part of the pancreas may be resected if much lacerated, especially if near the tail of the gland ; but care must be taken to avoid the main duct, the superior mesenteric artery, and the portal vein. Extensive disorganization of the gland can only be treated by gauze tampons and drainage.

Results. Of twenty-one cases of injury of the pancreas due to gunshot wounds fifteen were operated on and nine recovered ; all but one not operated on died.

After injury from stab wound, direct treatment, with careful suture of the wound in the pancreas, has been very successful.

Injury without external wound.

Operation. Delay will usually occur, as a diagnosis cannot always be made immediately; but as soon as signs of hæmorrhage or of inflammation manifest themselves an exploration will be advisable.

Results. In a case reported by Randall, operation six hours after the accident was followed by recovery. Garre (*Beiträge zur klin. Chir.*, June, 1905) reports a case in which a total transverse rupture of the pancreas was treated successfully by careful suture and drainage. The late

Prof. von Mikulicz (*Annals of Surgery*, July, 1903) reported 45 cases of pancreatic injury, 21 penetrating, 24 subcutaneous. Of the 21 penetrating wounds, 12 were gunshot and 9 stab wounds. Five of the 12 gunshot wounds were operated on and 3 recovered. Of the 7 not operated on all died. In 7 of the 9 stab wounds the pancreas was partly prolapsed; all were operated on and recovered. Of 2 that were not prolapsed, 1 recovered. Of the 24 subcutaneous injuries, 13 not operated on died, but of the 11 operated on, 7 recovered.

OPERATION FOR ACUTE PANCREATITIS

An early exploration from the front through the middle line above the umbilicus or from behind through the left costo-vertebral angle is indicated, in order, if possible, to relieve tension, to evacuate septic material, to secure free drainage, and to arrest the hæmorrhage, which leads to disintegration and necrosis of the pancreas. Even if no pus be found no harm should accrue from such an exploration, which can be made in a few minutes. After establishing the diagnosis by abdominal section, a posterior incision in the left costo-vertebral angle will sometimes enable the diseased organ to be very freely drained for the evacuation of pus and gangrenous material without risk to the general peritoneal cavity and with little danger of retained septic matter, as the drainage will be a dependent one. If, however, the inflammatory collection of the tensely distended and inflamed gland be incised from the front, as is generally advisable, gauze packing and gauze drainage may usually be relied on to prevent general infection of the peritoneum.

If there be signs of an obstructed common bile duct, the gall-bladder should be drained, and if gall-stones be discovered they should be removed, if this can be done without seriously adding to the length of the operation or imperilling life by adding to the shock; otherwise they may be left and removed on a subsequent occasion if free drainage of the bile passages can be secured.

After-treatment. The after-treatment will be chiefly directed to combating shock and keeping up the strength until the *materies morbi*, both local and general, can be thrown off.

Results. Out of six cases of acute pancreatitis under my care, operation was performed on four, of which two recovered. Of two cases where operation was not consented to, and where medical treatment alone was carried out, death occurred in the first case on the third day and in the second case after a week's illness, attended in both with great pain and incessant vomiting.

OPERATION FOR SUBACUTE PANCREATITIS

The subacute form of pancreatitis is more amenable to treatment, as the indications are so much more definite and there is more time for careful consideration.

Operation. A median incision above the umbilicus will enable the operator to palpate the pancreas and to locate any incipient collection of pus, which, if practicable, should then be evacuated by a posterior incision in the left or right loin or in the costo-vertebral angle. If the posterior incision be thought impracticable, the collection of pus may be removed by aspiration and the cavity opened and packed with gauze, which may be brought forwards through a large rubber tube, which procedure will, in the course of from twenty-four to forty-eight hours,

FIG. 93. ABSCESS OF THE PANCREAS.

establish a track isolated from the general peritoneal cavity. It is important in these cases to see that the cause is removed, if that be possible—for instance, gall-stones or pancreatic calculi—so that if recovery occurs there may be no fear of relapse.

Results. Out of nine cases of abscess of the pancreas under my care, seven were operated on, with recovery from operation in six, though in one of the cases the relief was only for a few weeks and in another for a few months.

In abscess of the pancreas, which usually assumes the form of subacute pancreatitis, the suppurating process is limited by a pouring out of lymph, so that, should the patient survive the initial more acute stage, and discovery of the pus-containing cavity be made, the condition is one decidedly amenable to treatment by drainage. In one of my cases an abscess formed and was opened in the right loin of a young man, aged twenty-four years. It had been mistaken for a perirenal abscess, yet the kidney was quite healthy and the grumous pus had come from

the pancreas and passed behind the peritoneum covering the second part of the duodenum. The patient recovered completely. In another case an abscess was opened in the left iliac region that had apparently started from the body of the pancreas and which had burrowed in the same way behind the peritoneum. The patient recovered from the operation, but developed trouble in the left side of the thorax and died suddenly several weeks later. In one case the abscess was subphrenic. In another, where the symptoms were rather acute and the patient was extremely ill, pus was discovered between the liver and the stomach, and although drainage was apparently complete, the patient succumbed in a few days to exhaustion due to the septic process that had been initiated before the abscess was opened. In the other two of my cases, the sequence of suppurative catarrh, abscesses of the pancreas were successfully drained through a tube in the common bile duct after removing the gall-stones which had obstructed Wirsung's duct. In one of these cases the patient, a woman aged seventy-two years, recovered completely. The other, a man aged forty years, recovered from the operation, but three months afterwards died from exhaustion, and at the necropsy the empty abscess cavity was discovered in the head of the pancreas, the rest of the gland being affected with chronic interstitial inflammation.

A search through literature reveals a considerable number of pyæmic abscesses of the pancreas, but those resulting from subacute pancreatitis have been rarely recorded. Besides seven operations for abscess of the pancreas with two deaths above referred to, there have been seven others recorded with three deaths. Thus, of fourteen cases five died, giving a mortality of 35·6%.

OPERATION FOR PANCREATIC LITHIASIS (PANCREO-LITHOTOMY)

Pancreatic calculi are so rare that Oser, in 1903, could only find seventy recorded cases. The calcareous composition of pancreatic calculi renders them opaque to the X-rays and affords a means of differential diagnosis between them and gall-stones. This fact I had the honour of first pointing out in 1904. The accompanying X-ray photograph shows the comparison (see Fig. 95).

Operation. An incision 3 to 4 inches long, 1 inch to the right of the middle line, will be found the most convenient, as the fibres of the right rectus can be split and the incision lengthened upwards and downwards without unnecessarily weakening the abdominal wall. A sand-bag under the lumbar spine will bring the gland several inches nearer the surface.

If the opening of the duct of Wirsung has to be explored, the second

part of the duodenum may be incised and the papilla common to the bile duct and pancreatic duct laid open, when the edges of the opened diverticulum of Vater can be seized with small catch-forceps and drawn to the surface; a probe or fine forceps can then be readily passed into Wirsung's duct and any concretion removed.

If the calculi be more deeply placed in the ducts, the pancreas may be exposed either through the gastro-hepatic omentum by drawing the stomach downwards, or by lifting the stomach it may be reached through an opening in the omentum; or by raising the colon it may be approached by a slit in the transverse mesocolon. By peeling the duodenum from

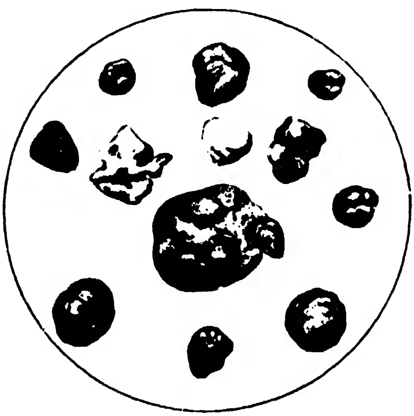


FIG. 94. DRAWING FROM A SIMPLE PHOTOGRAPH OF GALL-STONES AND PANCREATIC CALCULI REMOVED FROM ONE PATIENT BY THE AUTHOR.

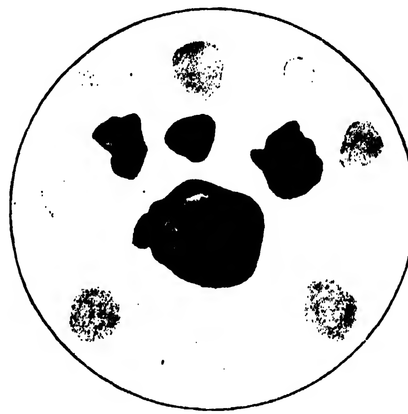


FIG. 95. SKIAGRAM OF THE PREVIOUS PHOTOGRAPH. Showing that the pancreatic calculi are opaque to the X-rays.

the parietes the back of the pancreas may be readily reached. The calculi may be then cut down on and extracted by a scoop or forceps. Any bleeding must be arrested by ligatures. The duct can be sutured and the incision in the gland must be brought together by buried sutures, the peritoneal covering being coapted by a continuous suture. If leakage be feared, a gauze drain may be applied; but the position may be difficult for this, and if it has to be done the gauze must be surrounded by a rubber drainage tube and brought through it to the surface. In my case of pancreo-lithotomy referred to below, the closure of the gland was so secure as not to require gauze packing, and the result justified its not being used. When the duodenum has been opened it must be closed in the usual way by a muco-muscular and serous suture, the latter being of fine celluloid thread. The incised papilla need not be sutured.

If a calculus be felt in the head of the gland, but not in the duct of

Wirsung, it may be reached by incising the peritoneum over the duodenum and separating it gently from the head of the pancreas, or if more deeply placed near the back of the gland the reflection of peritoneum from the duodenum to the abdominal wall may be incised and the duodenum may then be displaced inwards, when the back of the pancreas will be exposed, and, if thought advisable, it may be incised and treated as in the incision from the front.

Results. In a case which came under my care on February 13, 1903, four calculi were removed from a woman aged fifty-seven, one from the duct of Santorini, or one of its branches, by direct incision into the pancreas close to the common duct, the opening being afterwards closed by deep and by peritoneal sutures; the second and third stones were reached through an incision in the duodenum by laying open the papilla, when by means of fine forceps a calculus was removed out of Wirsung's duct, along which a probe was afterwards passed for 2 inches, and a fourth concretion was removed by direct pancreatotomy from the middle of the duct of Wirsung, the stone being reached by incising the gastro-hepatic omentum, drawing the stomach downwards, incising the pancreas freely, and opening the duct directly on to the stone, which was of the size of a small bean. The duct was then closed with catgut, the wound in the body of the pancreas being sutured so as to leave no dead space and the peritoneal wounds being closed without direct drainage. The right kidney pouch was then drained, as some infected bile had escaped. Recovery was ultimately complete. This is, apparently, the first case in which either the duct of Wirsung or the duct of Santorini has been deliberately opened and, after the removal of a calculus, closed by a suture.

A very exhaustive search through English and foreign literature has only resulted in the discovery of five operations for pancreatic calculi. Mr. A. Pearce Gould's case, operated on March 3, 1896, died on the twelfth day from exhaustion. In Dr. Dalziel's case a stone of the size of a very large pea was removed from the pancreatic duct through an incision in the duodenum, the opening in the duct being stitched to the wound in the posterior wall of the duodenum. As the bile duct was clear there was no jaundice. A good recovery followed. In Mr. B. G. A. Moynihan's case a pancreatic stone was removed from the ampulla of Vater through an incision in the duodenum, and the patient recovered. In Dr. L. W. Allen's case two calculi were removed from a cyst between the lesser curvature of the stomach and the liver. The patient died on the fifth day after operation.

OPERATION FOR PANCREATIC CYSTS

Cysts of the pancreas may be divided into false and true. The false or pseudo-cysts may be due to a distension of the lesser peritoneal sac, or to a localized collection of fluid in the neighbourhood of the pancreas.

True cysts may be due to retention from various causes, to parasitic disease—*e.g.* hydatids—to new growths, as in proliferation cysts, and to hæmorrhage. A few cases of congenital cystic disease have been recorded.

The physical signs of cysts of the pancreas are by no means constant. A consideration of the peritoneal reflections from the pancreas on to the viscera, and how they influence the ultimate position and relations of the pancreatic cysts, will render the reason for this clear.

The explanation of these variations, which may, and often do, lead to difficulties in diagnosis, is an anatomical one, and depends on the site of the origin of the cyst, which in making its way to the surface proceeds in the line of least resistance, and is thus influenced by the reflections of the peritoneum and the arrangement of the viscera overlying the gland.

Fig. 98 shows the position of a number of cysts of the pancreas upon which I have personally operated, and illustrates the great variety in the clinical characters.

Aspiration and other forms of tapping are inadequate and ineffectual methods, which are attended with more danger than is the operation of incision and drainage. They are, therefore, not to be recommended, even for diagnostic purposes. Occasionally complete extirpation of the cyst may be performed, as in a case that came under my care, where the tumour returned a few months after it had been apparently successfully treated by drainage; but the greater difficulty in performing excision, its impracticability in certain cases, and the greater mortality attending it, as compared with the operation of incision and drainage, make it quite clear that drainage should always have a fair trial unless the circumstances prove to be very exceptional, as, for instance, in the case of a cyst of the tail of the pancreas, or in the case of a pedunculated cyst.

As to the situation for drainage, that will depend on circumstances. The tumour will usually be attacked most readily from the front at a point where it very nearly reaches the surface. Occasionally, however, it may be drained from the loin.

Fistula does not, as a rule, follow the drainage of pancreatic cysts, but in some cases a small fistula may persist and may go on for years without hurt to the patient and with very little discomfort.

The following is a description of the operation usually performed:

An incision is made through the parietes opposite the most prominent part of the cyst. When the peritoneum is opened, the finger can be employed to ascertain the relations of the cyst and its attachments. If the stomach be in front of the cyst, it will be better to displace that viscus upwards and to make a slit through the great omentum in order to expose the cyst-wall; if the colon be in front, it may be displaced downwards. But no rule can be formulated, as the cyst must be reached in the most convenient way, and that can be ascertained only when the abdomen is open. By means of an aspirator the fluid is then drawn off, and an opening made in the cyst sufficiently large to allow of a drainage tube being inserted. The tube may then be fixed to the margin of the incision in the cyst by a single catgut suture, and if the opening into the cyst be surrounded by a purse-string suture, which can be tightened around the tube, all fear of leakage from the cyst into the peritoneal cavity is avoided. Any vessels coursing over the cyst must be avoided, but should an artery or vein be pricked, it must be caught between pressure-forceps and ligatured.

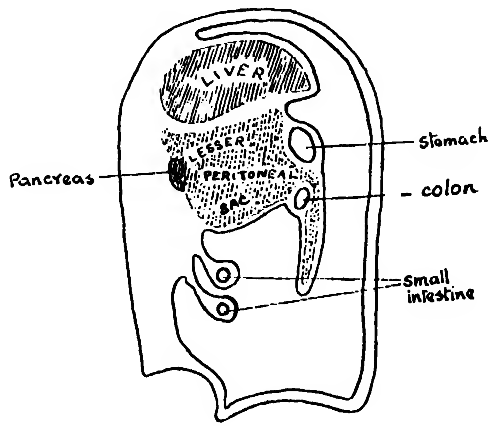


Fig. 96. Pseudo-cyst of the Pancreas due to Effusion in the Lesser Sac of the Peritoneum.

The edge of the cyst may then be fixed to the aponeurosis by three or four sutures, but it is better not to attach it to the skin. The abdomen is then closed, and if the tube be sufficiently long it will readily drain into a bottle containing some antiseptic fluid. If, on exploration, the cyst be found to have a narrow attachment to the pancreas and the adhesions are not too extensive, it may possibly be shelled out, or the pedicle may be ligatured, but this is rarely feasible.

Some surgeons have suggested the desirability of fixing the cyst to the surface and only opening it after a few days, when adhesions have been formed, but this operation *à deux temps* seems to be quite unnecessary.

Results. In the cases that have come under my personal observation, one cyst was enucleated, recovery following; drainage was carried out in ten cases of true cyst, recovery following in nine; whereas of two pseudo-cysts, one due to traumatic hæmorrhagic pancreatitis and the other to necrotic pancreatitis, one recovered.

Of the 160 cases of operation recorded by others, there were 140 recoveries; in 4 cases the ultimate issue was doubtful; in 8 out of the 140 reported recoveries after operation the patients died subsequently—1 from diabetes four months later, 1 from hæmorrhage one and a half years later, 1 from concomitant peritonitis seven weeks later,

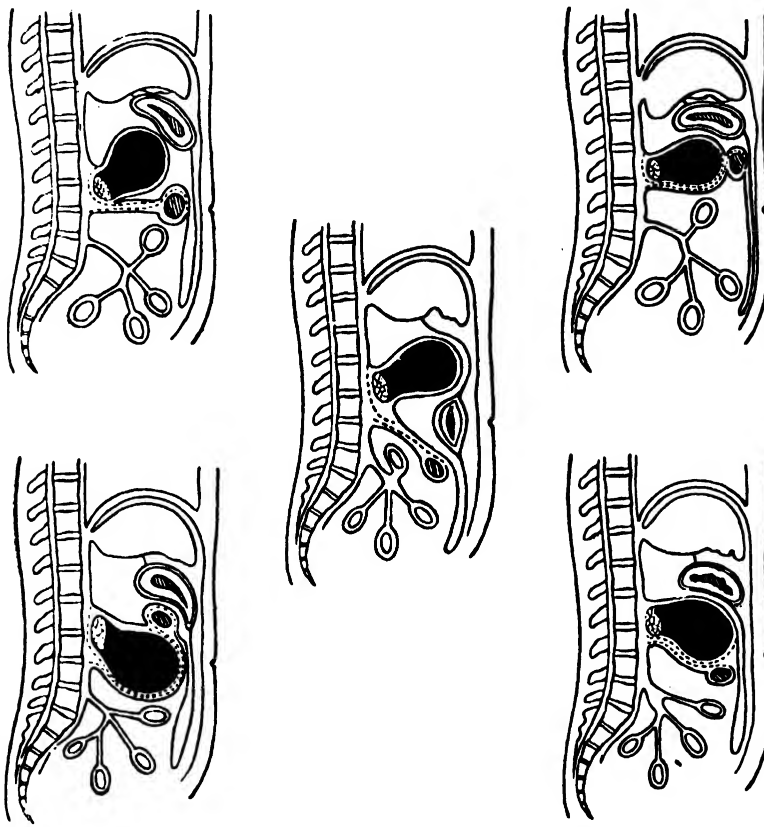


FIG. 97. CYSTS OF THE PANCREAS ADVANCING TOWARDS THE SURFACE BY DIFFERENT ROUTES.

1 from a zymotic fever a few weeks later, and 4 from causes not stated a few weeks later. Death is recorded as the result of operation in 20 cases. In 5 of these the cause of death and the time after operation are not given. One patient died in collapse, 1 died before operation could be completed (the next day), 1 died from 'ileus', 1 died eighteen days after operation (cause not stated), 2 died from shock, 1 died from gangrene of the pancreas, and 8 died from peritonitis. Of these latter, 1 died at an interval not stated, 1 after ninety-six hours, 1 after six days, 1 after an

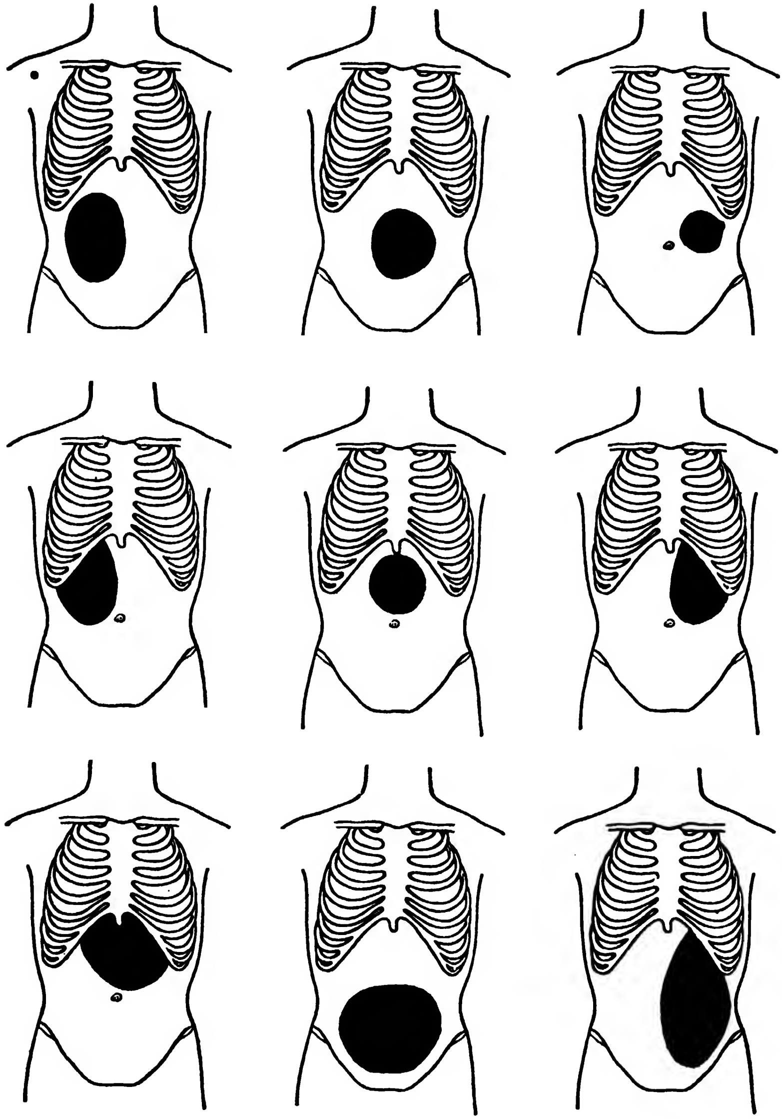


FIG. 98. DIAGRAM OF VARIOUS PANCREATIC CYSTS THAT HAVE COME UNDER THE OBSERVATION OF THE AUTHOR AND WHICH ILLUSTRATE THE SIMULATION OF OTHER TUMOURS.

exploratory incision, 2 after two days, 1 on the eighth day, and 1 on the second day. In 138 cases incision and drainage were performed, with 16 deaths, equal to a mortality of 11·6 %. In 15 excision was performed,

with 3 deaths, equal to a mortality of 20 %. In 7 partial excision was done, with 1 death, equal to a mortality of 14·3 %.

Although larger numbers have been reported by others, the above figures are as nearly correct as possible, for on verifying the records sometimes the same case had been reported twice, in others wrong dates had been given, and in a few the details were so meagre that the nature of the operation was not given. The evidence is clearly in favour of drainage, but the mortality should certainly be reduced by one-half.

Hydatid cysts must be treated by drainage and evacuation of the daughter cysts, and on no account must excision of the cyst-wall be attempted, though in some cases it may be possible to completely evacuate the endocyst and thus to expedite recovery.

OPERATION FOR GROWTH IN THE PANCREAS

Tumours of the pancreas are usually of a malignant nature.

Operation. Surgical treatment is not very hopeful, and has usually been undertaken under the idea that the cause of the jaundice might be a removable one, or that drainage of the bile ducts might afford relief, but if the disease has involved the head of the pancreas it is hopeless however treated.

Operation may be radical or palliative. Ruggi, of Bologna, removed through the loin a cancer of the pancreas weighing 23 ounces. It was probably growing from the tail of the gland. Complete recovery followed and the patient was well for three months, after which secondary disease developed and the patient died at the end of six months. Professor Ruggi himself has kindly furnished these details. Billroth, in 1894, removed the whole pancreas and the patient recovered. Cades's was the third successful case, in 1895, a tumour of the tail of the pancreas of the size of a child's head being removed. Terrier, in 1892, removed a tumour weighing 5 pounds, but lost his patient. Franke, in 1901, removed the whole of the pancreas with recovery of the patient. Of sixteen operations for removal of solid tumours of the pancreas, eight recovered; which, considering the difficulty of the operation and the depth of the organ to be operated on, is better than one would have expected. Successful pancreatectomies, it will be seen, are exceptional and are feasible only where the growth is not involving the head of the gland; they, however, clearly demonstrate that a tumour of the body or of the tail of the pancreas may be removed with a chance of recovery, and should the disease be primary, and no secondary growths or glandular involvement have occurred, considerable prolongation of life is quite possible.

Desjardins (*Rev. de Chirurgie*, June 10, 1907) advocates the more frequent performance of pancreatectomy, and has proposed an operation which involves complete excision of the duodenum, partial excision of

FIG. 99. CANCER OF THE HEAD OF THE PANCREAS. Drawing of Specimen No. 1414, St. Thomas's Museum. Showing dilatation of the bile ducts, gall-bladder, and Wirsung's duct.

the pancreas, cholecystenterostomy, and gastro-enterostomy. The illustrations are admirable, and if the operation of complete pancreatectomy should ever be considered justifiable, this method proposed by Desjardins would seem to commend itself as being mechanically possible.

SECTION III

OPERATIONS UPON THE CENTRAL NERVOUS SYSTEM

PART I

OPERATIONS UPON THE SKULL AND BRAIN

BY

L. BATHE RAWLING, M.B., B.C. (Cantab.), F.R.C.S. (Eng.)

Assistant Surgeon to St. Bartholomew's Hospital

CHAPTER I

CRANIO-CEREBRAL TOPOGRAPHY

The surgeon who is called upon to carry out operations on the skull and brain must possess an accurate knowledge of the anatomy of the parts involved. Added to this, he must have at his command some simple method of depicting on the surface of the skull the more important structures.

The more complicated systems of cranio-cerebral topography are of little practical value to the surgeon. Simplicity is essential, and the following outline will be found to furnish an adequate practical guide.

Firstly, the skull can be divided into two lateral halves by the surface-marking of the superior longitudinal venous sinus.

The superior longitudinal sinus. This sinus originates at the crista galli and, passing backwards along the attached margin of the falx cerebri, terminates at the internal occipital protuberance. It may be represented by a line drawn from the base of the nose (the nasion), over the vertex of the skull, to the external occipital protuberance (the inion)—this line corresponding in its course to the occasionally persistent metopic suture between the two halves of the frontal bone, to the sagittal suture between the parietal bones, and to the middle line of the upper or tabular portion of the occipital bone.

Secondly, each lateral half of the skull can be subdivided into supra- and infratentorial regions by a line which marks the external attachment of the tentorium cerebelli; in other words, by the line of the lateral sinus.

The lateral sinus. This sinus is represented by a line presenting a slight upward convexity, which is drawn from the external occipital protuberance to the upper and posterior part of the mastoid process of the temporal bone.

The infratentorial region. The cerebellum lies wholly beneath the tentorium cerebelli, and it is obvious that, in operations carried out over this portion of the brain, the surgeon is limited in his field of exposure, above by the line of the lateral sinus, and on either side by the posterior border of the mastoid process. The division between the halves of the cerebellum may be represented by a line drawn vertically

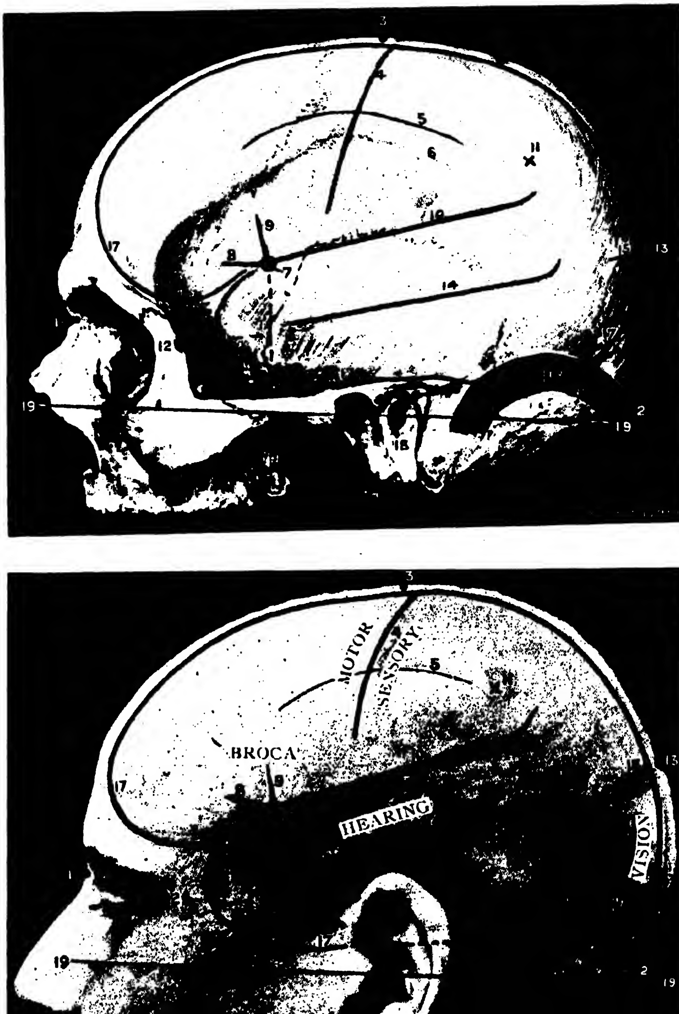


FIG. 100. CRANIO-CEREBRAL TOPOGRAPHY. 1, The nasion; 2, The inion; 3, The mid-point between nasion and inion; 4, The Rolandic fissure; 5, The superior temporal crest; 6, The inferior temporal crest; 7, The Sylvian point; 8, The anterior horizontal limb of the Sylvian fissure; 9, The vertical limb of the Sylvian fissure; 10, The posterior horizontal limb of the Sylvian fissure; 11, The parietal prominence; 12, The malar tubercle; 13, The lambda; 14, The first temporo-sphenoidal sulcus; 15, The external parieto-occipital sulcus; 16, The lateral sinus; 17, 17, 17, The level of the base of the cerebrum; 18, The external auditory meatus; 19, 19, Reid's base line. (*Reproduced, by the permission of Mr. H. K. Lewis, from the author's work on 'Landmarks and Surface-markings'.*)

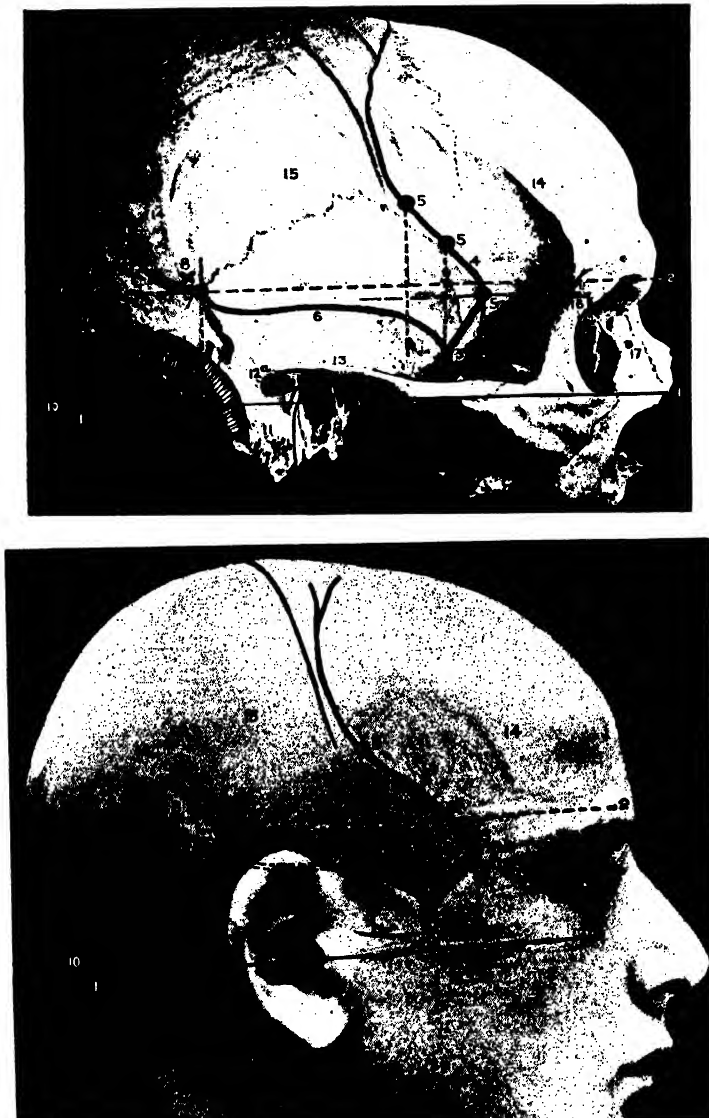


FIG. 101. CRANIO-CEREBRAL TOPOGRAPHY. 1, 1, Reid's base line; 2, 2, A line parallel to the above at the level of the supra-orbital margin; 3, The middle meningeal artery; 4, The anterior branch; 5, 5, 5, The three sites for trephining; 6, The posterior branch; 7, The site for trephining; 8, The point for trephining to reach the descending horn of the lateral ventricle; 9, The lateral sinus; 10, The inion; 11, The mastoid process; 12, Macewen's suprameatal triangle; 12*a*, The mastoid antrum; 12*b*, The facial nerve; 13, The suprameatal and supramastoid crests; 14, 14, The temporal crest; 15, The temporal fossa; 16, The external angular frontal process; 17, The tendo-oculi attachment; 18, The lachrymal groove. (*Reproduced, by the permission of Mr. H. K. Lewis, from the author's work on 'Landmarks and Surface-markings'.*)

downwards from the external occipital protuberance to the nuchal region. This line also represents the surface-marking of the occipital sinus and falx cerebelli.

The supratentorial region. Brief allusion must be made to certain landmarks that aid in the representation of structures situated in this region :—

(*a*) *The external angular frontal process.* The suture between the external angular frontal process and the corresponding process of the malar bone lies immediately above the central point of the outer border of the orbital cavity.

(*b*) *The malar tubercle.* A slight prominence on the posterior border of the frontal process of the malar bone, about $\frac{1}{4}$ inch below the external angular frontal process.

(*c*) *The temporal crest.* A prominent ridge that is directed upwards and backwards from the external angular frontal process. The crest cuts across the lower portion of the parietal bone, passing below the parietal prominence, and curves downwards towards the upper and posterior portion of the mastoid process. It terminates by becoming continuous with the upper root of the zygomatic process. The crest consists of two parts, the upper and lower temporal crests. To the upper is attached the temporal fascia, to the lower the temporal muscle. The lower crest is almost invariably the more prominent.

(*d*) *The parietal prominence.* The central and most prominent part of the parietal bone. It indicates the point at which ossification commenced, and lies about $\frac{3}{4}$ inch above the termination of the posterior horizontal limb of the fissure of Sylvius.

(*e*) *The zygoma.* When traced in the backward direction the zygoma is found to divide immediately in front of the ear into three roots, of which the anterior, merging into the eminentia articularis, and the middle, aiding in the formation of the post-glenoid process, are of no practical utility in surface-marking. The upper or posterior root sweeps backwards above the external auditory meatus to become continuous with the suprameatal and supramastoid crests, the former of which forms the upper boundary of *Macewen's suprameatal triangle*, a triangular depression at the upper and posterior border of the external auditory meatus. This triangle may be taken as representing the opening of the mastoid antrum into the middle ear.

These landmarks having been determined, the following structures may be mapped out on the surface of the skull.

The middle meningeal artery. This artery is given off from the internal maxillary; after a short extra-cranial course it enters the skull through the foramen spinosum, and soon divides into

two main terminal branches. The site of division corresponds to a point situated just above the centre of the zygoma.

The *anterior branch* passes at first in a forward and upward direction towards the anterior inferior angle of the parietal bone, and then turns upwards and backwards towards the vertex of the skull. The main 'danger zone' in the course of this vessel may be mapped out by taking points which lie respectively 1, 1½, and 2 inches behind the external angular frontal process and an equal distance above the upper border of the zygoma. A line uniting these three points represents that part of the anterior division of the middle meningeal artery which is most liable to injury and which therefore most frequently requires exposure.

The uppermost point may, however, be regarded as the 'site of election' for exposure of the artery, as, in trephining over either of the two lower points, difficulty may be experienced in the removal of the disk of bone, since the posterior border of the great wing of the sphenoid tails off on to the anterior inferior angle of the parietal bone in such a manner that to effect a clean removal of the disk of bone is often impossible. Another disadvantage to trephining low down lies in the fact that in about 30 to 40% of cases the artery occupies, in that situation, a canal in the bone.

The *posterior branch* passes almost horizontally backwards, parallel to the zygoma and supramastoid crest, towards the posterior inferior angle of the parietal bone. The vessel can readily be exposed by trephining over the point at which a line drawn backwards from the upper border of the orbit, parallel to Reid's base-line,[1] cuts another line directed vertically upwards from the posterior border of the mastoid process.

Both branches of the middle meningeal artery possess important relations to the cortex cerebri, the anterior branch passing upwards in relation to the precentral or motor area, traversing, from below upwards, the motor speech area (on the left side of the head), the centres for the movements of the face, upper extremity, trunk, and lower extremity. The posterior branch, on the other hand, passes backwards in relation to the temporo-sphenoidal lobe, one of the so-called 'silent areas' of the brain. Throughout their course the middle meningeal vessels lie between the dura mater and the bone.

The lower limit of the cerebrum. The lower limit of the cerebrum can be mapped out in the following manner: From a point situated about ½ inch above the nasion a line is drawn outwards which follows the curve of the upper border of the orbit as far as

[1] Reid's base-line is a line drawn around the skull, starting in front at the lower border of the orbit and passing through the central point of the external auditory meatus.

the external angular frontal process, thence curving upwards and backwards to the Sylvian point (see below). The temporo-sphenoidal lobe sweeps forwar s to the posterior border of the malar bone, and its lower limit lies practically flush with the upper margin of the zygoma. At and behind the ear the lower limit of the cerebrum corresponds to the suprameatal and supramastoid crests, subsequently following the curve of the lateral sinus from the mastoid process to the external occipital protuberance.

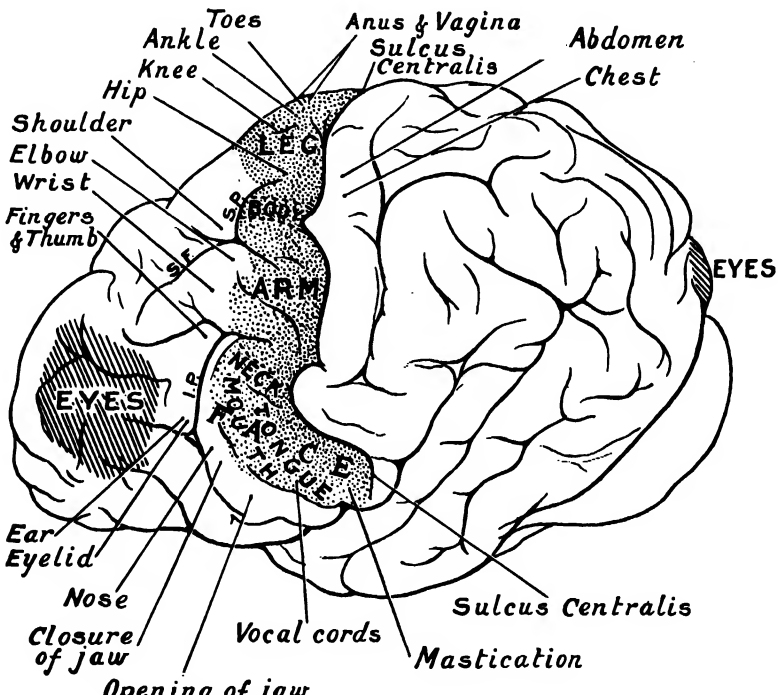


FIG. 102. THE MOTOR AREA AND ITS SUBDIVISIONS ON THE LATERAL ASPECT OF THE CEREBRUM OF THE CHIMPANZEE. (*Sherrington and Grünbaum.*)

The Sylvian point and fissure. The Sylvian point represents the site of divergence of the three limbs of the Sylvian fissure. It lies $1\frac{1}{4}$ inches behind the malar tubercle and $1\frac{1}{2}$ inches above the upper border of the zygoma. The main posterior horizontal limb passes backwards and upwards to a second point situated $\frac{3}{4}$ inch below the parietal prominence.

The vertical limb is directed upwards for about 1 inch, whilst the anterior horizontal limb passes forwards for about the same distance.

The fissure of Rolando. This, from a surgical point of view, the most important fissure of the brain, is represented as follows: A point is taken in the median antero-posterior line which lies ½ inch behind the mid-point between nasion and inion, and from this point a line is drawn, for 3½ to 4 inches, towards the mid-point of the zygoma. This line is inclined to the median antero-posterior line at an angle of 67½° (three-quarters of a right angle).

The parieto-occipital and first temporo-sphenoidal fissures. In the representation of these two fissures, two points

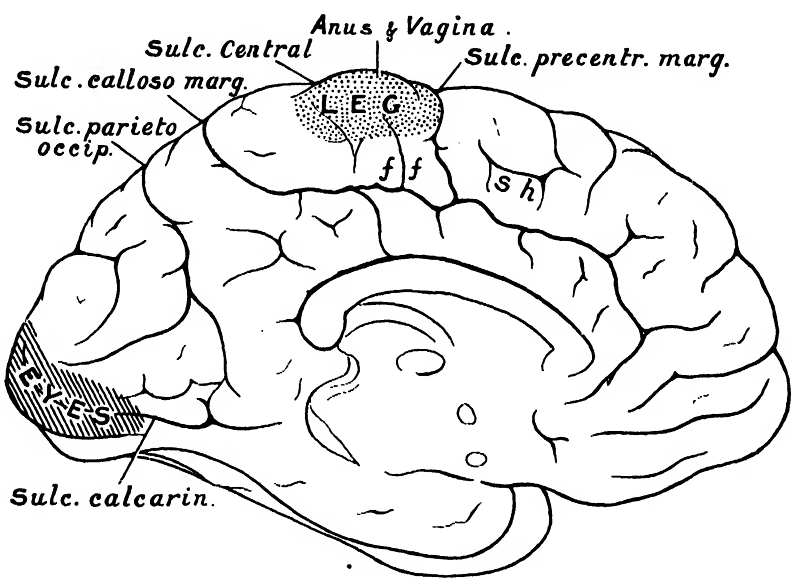


FIG. 103. THE MOTOR AREAS AND CENTRES ON THE MESIAL ASPECT OF THE CEREBRUM OF THE CHIMPANZEE. (*Sherrington and Grünbaum.*)

require to be determined—the malar tubercle and the lambda. Allusion has already been made to the former; the latter is usually readily located as the point of intersection of the parietal and lambdoid sutures. A line uniting these two points corresponds in its middle third to the temporo-sphenoidal fissure, and in its posterior inch or so to the external parieto-occipital sulcus, a fissure separating the occipital and parietal lobes of the brain.

The cortical motor and sensory areas. The researches of Sherrington and Grünbaum,[1] Campbell,[2] and others tend to show

[1] *Proceedings and Philosophic Transactions of the Roy. Soc.*, 1901.
[2] *Localization of Cerebral Function.* Camb. Univ. Press, 1905.

that the cortical motor areas are situated entirely anterior to the central fissure or fissure of Rolando, extending above slightly on to the mesial aspect of the brain, and spreading in the downward direction practically to the fissure of Sylvius. In the anterior direction there is no absolute line of demarcation, the motor region spreading slightly, by means of gyri annectantes, on to that part of the brain which lies immediately anterior to the precentral sulcus. The motor strip is rather less than $\frac{3}{4}$ inch in breadth.

The motor area corresponds, from above downwards, to the movements of the opposite lower extremity (toe to hip), trunk, upper extremity (shoulder to fingers), neck and face. It is a point of some general utility to bear in mind that the temporal crest intervenes approximately between the regions responsible for the movements of the upper extremity (above the crest) and those for the movements of the muscles of the head and neck (below the crest).

On the left side of the head, the motor speech area of Broca corresponds to that part of the brain which lies in the angle between the anterior and posterior horizontal limbs of the fissure of Sylvius.

The 'primary registration' of 'common sensation' probably occurs in the post-central gyrus, immediately posterior to the fissure of Rolando. The post-central sensory area occupies a position behind the fissure of Rolando very similar in extent to that occupied by the motor area in front of that fissure.

Primary visual impressions are received in the occipital lobe, more especially on the mesial aspect thereof, and auditory impulses in the first temporo-sphenoidal lobe.

In a work dealing with Operative Surgery, it is quite unnecessary to enter into further detail with regard to cerebral localization, and for a complete account of the investigations which have been carried out on the cortical motor and sensory areas the reader is referred to the works of Sherrington and Grünbaum and Campbell.

CHAPTER II

THE SPECIAL TECHNIQUE OF OPERATIONS UPON THE SKULL AND BRAIN

GENERAL CONSIDERATIONS

In order to avoid recapitulation, it will be convenient to group together the various details to which it will be necessary to allude in connexion with the special technique of operations upon the skull and brain. The advantage of such a method will become apparent when it is realized that, not infrequently, the difficulty of diagnosis is so great that the surgeon is called upon to carry out an extensive operation when all preliminary considerations pointed to one of a much more simple nature: insomuch as the success of the operation so often hinges on the more minute preparatory and operative details, the same preparation and the same care must be devoted to a comparatively simple case as to one in which the surgeon is prepared to devote much time and much thought.

Preparatory treatment. A considerable difference of opinion exists with regard to the extent to which the scalp should be shaved and the time at which this procedure should be carried out. Some surgeons advocate that the head should be completely shaved two or three days previous to the operation, and that, during the intervening time, fomentations should be applied—a method both inconvenient to the patient and unnecessary. Others urge that all shaving and cleansing should be postponed till after anæsthesia has been induced—a method that presents certain advantages if one has to deal with a very nervous patient, but materially increasing the time during which the patient is under the influence of the anæsthetic. It would appear, however, that although concessions must be made occasionally, the shaving being restricted to a limited region of the head, all such incomplete methods add to the risk of infection. The surgeon can guarantee more readily an aseptic result after complete shaving of the scalp and eyebrows, this proceeding being carried out on the evening previous to the day of operation, and the scalp protected during the night with a nightcap or dressing.

It is often stated that the scalp is difficult of sterilization. Experi-

ence shows, however, that such statements are devoid of all foundation. Good results may be obtained by adopting the following mode of skin purification :—

(1) Shave completely both scalp and eyebrows.

(2) Scrub thoroughly with nail-brush, soap, and hot water.

(3) Rub over with ether to remove the fats, then with a spirit solution of biniodide of mercury (1 in 500), and finally with an aqueous solution of mercury biniodide (1 in 2,000).

During the operation, no strong antiseptics are to be used. Sterilized water or saline solution, at a temperature between 110° and 115° F., suffices.

The anæsthetic. Needless to say it is absolutely essential that the anæsthetic should be administered by an anæsthetist of considerable experience in head operations.

Of the two anæsthetics at our disposal, chloroform is probably the more dangerous, a factor so much appreciated in America that ether is regarded in that country as the anæsthetic of choice. In this country, however, the administration of chloroform is generally approved, insomuch as it lowers the blood pressure, gives rise to a lesser degree of venous oozing, and 'by its essential paralysing action on the nerve-centres causes practically no after-excitement and but moderate headache. It is probably as frequently followed by obstinate sickness, but this depends on many considerations, and primarily on the dose itself' (Horsley [1]).

Furthermore, the danger of collapse during the administration can be avoided to a large extent by reducing to a minimum the quantity of drug used during the later stages of the operation, and by utilizing oxygen in conjunction with the chloroform.

Whether the anæsthetic be administered by the Vernon Harcourt apparatus, a method that regulates the dose used, or by the drop-method, one that presents equal advantages when given by a skilled anæsthetist, it is advisable to have oxygen ready to hand. The administration thereof, in conjunction with the chloroform, aids in the stimulation of the respiratory centres and lessens the venosity of the blood.

The position of the patient. Operations on the skull and brain were formerly carried out when the patient was in the ordinary recumbent position. More recently it has been advocated that the patient should be placed in the sitting position in an ordinary dental chair. This recommendation has been carried out successfully on many occasions for operations on the Gasserian ganglion.[2]

[1] *Brit. Med. Journ.*, Aug. 25, 1906.

[2] *The Surgical Treatment of Facial Neuralgia* (Jonathan Hutchinson).

The dental-chair position undoubtedly facilitates the manipulations of the surgeon by diminishing the hæmorrhage, but there is every reason to believe that the risk of shock is increased thereby. An intermediate course between the two extremes is generally to be advocated, the head portion of the operating table being raised in such a manner that the patient's body is inclined to the floor at an angle of about 30 degrees.

The manipulations of the surgeon may be facilitated by the use of some form of head-rest. Cushing recommends a special apparatus supported on a detachable tripod. In operations conducted on the cerebellar and occipital regions, the patient is turned completely on the face, the forehead resting on the head-rest and the shoulders on supports attached to the head of the table. The movements of the chest are unimpeded, and the anæsthetic is readily administered from below.

The precautions against shock. A general anæsthetic lowers the body temperature and results in shock more or less directly proportionate to the time during which the patient is under the influence of the anæsthetic. Moreover, it is almost inevitable that all head-operations should be accompanied by a considerable degree of shock apart from that attributable to the duration of the anæsthetic. Consequently, attention should be paid to the following details in order to diminish this tendency as far as possible:—

(*a*) Half an hour before the operation the patient should receive a hypodermic injection of $\frac{1}{4}$–$\frac{1}{2}$ gr. of morphia.

(*b*) The operating room should not be allowed to fall below a temperature of 70–75° F., and the table should be suitably heated.

(*c*) In all the more serious operations, the extremities should be bandaged firmly, from below upwards, in order to keep up a more or less constant peripheral surface-pressure. Crile[1] recommends, for the regulation of the surface-pressure in general, that the patient should be dressed in a special pneumatic suit which completely encloses the body—a method that is costly, inconvenient, and by no means essential.

(*d*) During the operation it is of the greatest importance that exposed brain should not be allowed to suffer from the cooling effects of the atmosphere. Horsley[2] recommends frequent or constant irrigation with normal saline solution at a temperature between 110° and 115° F. A solution at a lesser temperature merely tends to increase the bleeding, whilst any temperature above 115° F. tends to induce coagulation of the surfaces exposed thereto.

(*e*) The operation must be carried out with the utmost expedition, with a light hand, and with the avoidance of unnecessary hæmorrhage.

[1] *Annals of Surgery*, vol. xliv, p. 843.
[2] *Brit. Med. Journ.*, August 25, 1906.

The avoidance of hæmorrhage. The measures that have been recommended for the avoidance of unnecessary bleeding may be summarized as follows :—

1. *The preliminary ligature, or temporary closure of the main artery in the neck.* Such measures have been advocated as a preliminary step in the exposure and attempted removal of hæmorrhagic or large brain tumours. Both measures are open to the very serious objection that the necessary handling and manipulation of the brain lays the patient open to the grave risk of secondary œdema and softening of the brain. Crile[1] objects to the preliminary ligature of the vessel and states that the mortality resulting from such procedures may be estimated at about 2 to 3 %. He advocates, however, the temporary closure of the artery in suitable cases, and points out that clamps can be applied to the carotids for one hour or more without leading to any unpleasant remote effects. In general, however, it may be concluded that neither of these methods is to be followed.

2. *Sequestration anæmia.* It has also been recommended that as much blood as possible should be confined to the extremities by the application of tourniquets and towels to the arms and thighs in such a manner as to arrest the venous return without interfering with the arterial supply. The distal parts become dusky and swollen, and, after the application of the compression force for five or ten minutes, the softened pulse indicates that the desired result has been attained. The limbs are carefully wrapped up in cotton-wool, and, at the termination of the operation, the tourniquets slowly removed in order to allow of the gradual return of the retained blood to the system in general. This method has been recommended strongly by Dawbarn.[2] Good results are said to have been attained. It would appear, however, that the cases to which this method is applicable must be chosen with the greatest care, for it is obvious that there is some increased risk of inducing cerebral anæmia.

3. *Surface anæmia.* Harvey Cushing[3] recommends the application of a tourniquet around the lower circumference of the scalp with the object of controlling hæmorrhage from the vessels of the scalp. The tourniquet consists merely of a rubber ring, closely resembling Esmarch's tourniquet (see Fig. 104). It is applied over a sheet of gauze which completely covers in the head of the patient. The tourniquet passes from the region of the glabella in front, above or across the ears, to the lower occipital region behind. It will be found, as the ring is tightened up,

[1] *Annals of Surgery*, vol. xliv.
[2] *Annals of Surgery*, February, 1907.
[3] *Surgery, Gynæcology, and Obstetrics*, March, 1908.

that there is a tendency for the tourniquet to slip downwards over the patient's eyes. This is prevented by a tape which passes from the glabella to the occiput, and is there fastened. This tape also acts as a convenient surface-marking to the line of the superior longitudinal sinus. The formation of the scalp-flap is practically a bloodless procedure, all hæmorrhage from frontal, temporal, and occipital vessels being effectually controlled. Much valuable time is saved thereby, and the surgeon can at once proceed to carry out the further operative procedures. After the completion of the operation, the scalp-flap is approximated and sewn into position by salmon-gut sutures, introduced half an inch away from the margins of the incision and taking up the whole thickness of the scalp. Firm pressure is applied, dressings placed in position, and the tourniquet quickly removed. Cushing recommends that the dressings should be maintained in position by means of starch bandages.

Though the scalp-tourniquet cannot be used in operations conducted through the lower temporal region or on the cerebellar fossa, it is applicable to all other operations.

Cushing's tourniquet, by reason of the excessive diameter of the rubber-tube, is rather cumbersome, and the writer is accustomed to utilize tubing, about the diameter of a full-sized red rubber catheter, passed twice round the head, and secured with a pair of pressure-forceps. The tape is passed over the head, after Cushing's method.

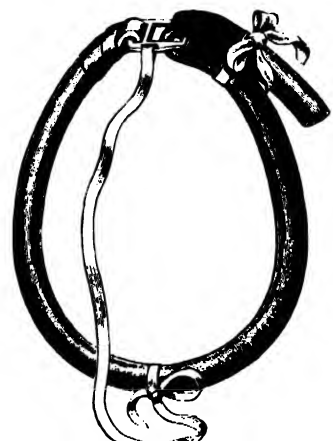


FIG. 104. HARVEY CUSHING'S SCALP-TOURNIQUET.

4. *Tampons.* Hæmorrhage from venous sinuses and from smaller superficial veins may be efficiently controlled by tampons of gauze, though, according to the late Professor von Bergmann,[1] the surgeon is very unwise if he pins his faith on the use of tampons alone. The more special indications for the use of tampons will be indicated in the section dealing with hæmorrhage from venous sinuses.

5. *Point-to-point ligature.* This method is advocated by von Bergmann and Horsley as offering the best means of controlling hæmorrhage. Every vessel is clamped and tied as encountered, whilst those which, from their anatomical position and structure, are incapable of being ligatured in this manner are underrun, with a fully-curved needle threaded with catgut, on either side of the bleeding point or of the proposed site of division.

[1] *System of Practical Surgery*, vol. i.

6. *The cautery.* Bleeding points, so situated that ligatures are unable to be applied, may be sealed with the actual cautery.

Other methods will be enumerated according to the special circumstances of the case, but unnecessary hæmorrhage can usually be prevented by attention to the foregoing details.

Protection of the parts exposed. Either of the following methods may be adopted to protect the exposed parts from infection :—

(*a*) Sterilized towels are stitched to the scalp all round the proposed area of operation. In the region of the forehead the towel is given to the care of an assistant to hold in such a manner that the operative field is cut off from the region over which the anæsthetist has control.

(*b*) The second method has been alluded to in dealing with the question of the application of the scalp-tourniquet, a sheet of gauze being thrown over the head of the patient and maintained in position by the tourniquet. The incisions are carried out by cutting through the gauze. This method is admirably suited to all operations in which the tourniquet itself is applicable.

CRANIECTOMY AND CRANIOTOMY

Craniectomy implies the formation of a scalp-flap and the exposure of the bone, trephining of the skull, and the enlargement of the gap in the skull to the required size and shape.

Craniotomy implies the formation of a flap of scalp and bone in one, the turning back of this osteoplastic flap, and the exposure of dura and brain to an extent proportionate to the size of the bone-flap.

The operative details, and the indications for each of these two methods, require further consideration.

CRANIECTOMY

In the formation of the scalp-flap, the surgeon will naturally be guided by his estimate of the part which it is desired to expose. In all cases, however, the flap must be so framed as to receive the best available blood-supply, and, although the arterial supply to the scalp is everywhere fairly free, yet it is usually advisable to form the flap in such a manner that it will receive along its base the superficial temporal or occipital vessels.

Operation. The point of the knife is entered at one extremity of the proposed flap, carried down to the bone, and the incision completed with a single sweep. If the scalp-tourniquet be used, there is no bleeding. Under other circumstances, hæmorrhage may be controlled during the formation of the flap by digital pressure applied over the base of the zygoma (superficial temporal arteries) and over the lower

occipital region (occipital vessels). All bleeding points should be clamped and tied at once, preferably with fine catgut.

Those clamps which are applied along the free margin of the flap may be allowed to remain till the termination of the operation, as they act as convenient retractors of the scalp-flap.

The pericranium is usually included in the scalp-flap. This is by no means essential, and, under certain circumstances, should be omitted (see p. 214).

Trephining. It is interesting to note the divergence of opinion with regard to the use of the hand-trephine. This instrument is absolutely condemned by some surgeons interested in cranio-cerebral surgery, especially by French and American surgeons. For instance, H. C. Masland[1] writes as follows: 'The hand-trephine requires but little notice. Its tendency, with the greatest care, to injure the dura or even the brain substance, is well known to us all. It destroys the vitality of the bone button, and makes an opening restricted to the diameter of the trephine. It is tiresome, dirty, and practically abandoned by advanced cranial surgeons.'

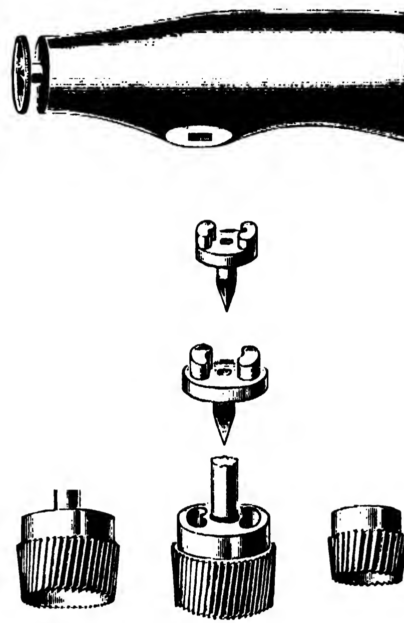


FIG. 105. THE HAND-TREPHINE.

Contrast now the above statement with the following: 'This operation (hand-trephining) is characterized by safety, easy execution, and the exactness and rapidity with which the bones of the vault of the skull may be perforated without producing concussion' (von Bergmann[2]).

And the following: 'After experience of saws, circular or straight, and trephines driven by electromotors, I find that the foregoing principle (the removal of the bone with the least possible pressure on the brain) can be most readily and quickly fulfilled by first removing a disc with the hand-trephine' (Sir Victor Horsley[3]).

Horsley's statement concludes by advocating, after the preliminary trephining, the application of the saw and bone-forceps for the further

[1] *Annals of Surgery*, vol. xliv, p. 161.
[2] *System of Practical Surgery*, vol. i, p. 326.
[3] *Brit. Med. Journal*, August 25, 1906, p. 419.

removal of bone, but the main question at issue as to the cleanliness, safety, and general excellence of the hand-trephine will readily be settled in favour of this instrument by all those who have experience in hand-trephining.

In order, however, that the instrument should be judged on its true merits, and in a fair spirit, it is essential that the right instrument should be used in the right manner.

Trephines are of many patterns, but the one that gives the most satisfactory results must possess certain characteristics.

(*a*) It should be of simple mechanism and strong.

(*b*) The handle should be of good size, shaped so as to fit the hand that grasps it, and weighing about 5 ounces. The shaft and head are either made in one, or so interlocked that no independent movement is possible, the movements of the handle being therefore directly transmitted to the shaft and head.

(*c*) The hollow head should be sharply toothed on the inferior or biting edge and bevelled externally, in continuity with the teeth, for a distance of $\frac{1}{2}$ inch. The external bevelling is arranged obliquely so that the actual cutting process is brought about during the act of supination of the forearm. In shape, the head should be conical, tapering slightly towards the cutting edge; the bone disk is thus more readily removed and there is no possibility of the instrument slipping suddenly as the bone is divided and injuring the dura mater.

(*d*) The pin of the trephine should project for about 2 centimetres and should be capable of ready removal. A pattern (see Fig. 105) which suits all requirements presents on the upper surface of the pin two kidney-shaped projections which fit into corresponding depressions on the under surface of the head of the trephine.

Trephines should be kept in three sizes—diameter $\frac{1}{2}$ inch, 1 inch, and $1\frac{1}{2}$ inches respectively. The intermediate size is the instrument advocated for ordinary trephining. The smallest should be used in the formation of the osteoplastic flap (see p. 203), and the largest for the removal of a disk of bone which includes within its circumference the area involved in a punctured fracture (see p. 217). The full-sized instrument may also be used in certain birth fractures (see p. 222).

The site of trephining having been determined, the scalp-flap turned down to its base, and the pericranium stripped away from the region of bone which it is desired to remove, the pin of the trephine is applied to the centre of that area. The trephine must be applied absolutely at right angles to the surface of the bone, and a grip on the bone attained before the pin is discarded. As soon as the teeth of the trephine attain the necessary grip, and as soon as a circle of uniform depth is defined,

the pin can be discarded, the trephine again introduced, and the operation continued.

The groove is deepened progressively, but at no period of the operation should much manual strength be applied. The movements of the trephine must always be kept under perfect control, and it should be borne in mind that the obliquity in the arrangement of the teeth only permits of the cutting process during the act of supination, so that it is only during that act that muscular effort is required.

It has been elsewhere stated that every skull should be explored as if it were extremely thin. This advice is possibly applicable to the novice, but a little experience in trephining will soon enable the operator to gauge accurately the depth to which the trephine has reached and to estimate the further manipulations necessary.

The firm nature of the external table will be readily appreciated; as soon as this resistance is overcome the trephine will be felt to bite through a softer structure, whilst the increased bone-dust and the venous oozing will make evident the fact that the instrument is cutting its way through the diploic tissue. Greater resistance is again encountered on meeting the internal table, warning the operator that the time has arrived when greater care must be exercised. At this stage the bone-dust must be periodically removed from the trephine circle, and the teeth of the trephine cleansed with an ordinary sterilized nail-brush. The depth of the groove must also be determined by the aid of some suitable instrument, in order that the surgeon may be certain that the circle is of uniform depth, or of that depth which is suited to the particular part of the skull on which the operation is being carried out. Any irregularities in the depth may be remedied by the application of a slightly increased pressure over the required section of the trephine circle.

If, after examination with some blunt exploring instrument, it be found that the bone is completely cut through on one side of the circle only, the trephine should be applied gently to the undivided part.

A useful method of demonstrating that the disk is almost free and ready for removal may be obtained by digital pressure, the disk giving to the pressure and showing that it is ready for elevation.

No doubt the rapid complete circumferential division of the bone is calculated to impress the onlooker, but, unless the operator has great experience in trephining and possesses complete control over the trephine, all such attempts are to be condemned on account of the attendant grave risk of damage to meningeal vessels and dura mater.

On the other hand, the bone-elevator (see Fig. 106) must not be used till the operator is satisfied that the complete disk is ready for removal,

the premature use of the elevator merely resulting in the splitting off of the external table and in further complication.

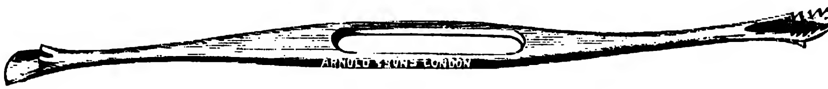


FIG. 106. HORSLEY'S DISK OR BONE ELEVATOR.

Especial care is required in operating in the temporal and cerebellar regions, where, owing to the absence of the diploic tissue, the two tables of the skull are practically in apposition; the same warning applies to all operations in children, not only on account of the thinness of the skull, but also because of the greater adherence of the dura mater to the overlying bone.

Too much stress cannot be laid on the necessity of avoiding damage to the meningeal arteries and dura mater, for such injuries frequently upset the whole plan of operation.

The hand-trephine undoubtedly possesses one great disadvantage. It is somewhat slow in manipulation, and, in operations carried out upon thick skulls, tends to tire the muscles of the operator's forearm and hand. Its comparative safety over all electrically or mechanically driven instruments acts, however, as its strongest recommendation, whilst the tiring effects can be diminished either by lowering the operating table, or by the surgeon standing on a stool, in either of which cases the trephining is carried out practically with the straight arm, the shoulder muscles thereby relieving the muscular tension of the forearm and hand. Under no circumstances must any body weight be transferred to the trephine.

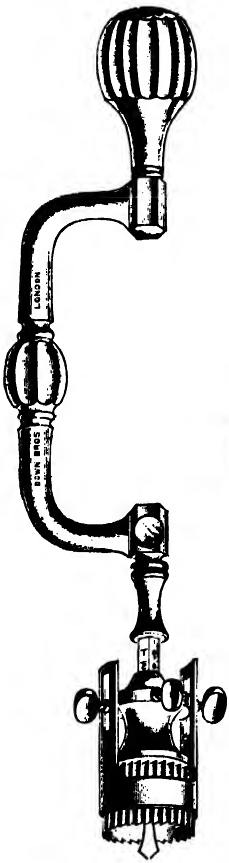


FIG. 107. TREPHINE USED AFTER THE STYLE OF A CARPENTER'S BRACE.

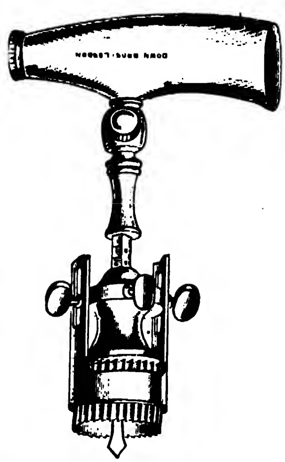


FIG. 108. THE SAME INSTRUMENT USED AS A HAND-TREPHINE.

With the object of saving time and energy, various trephines have

been invented, and allusion may be made to the two following types :—

(*a*) A trephine constructed after the type of the carpenter's brace (see Fig. 107) : an instrument liable to get out of order, less readily sterilized, and, above all, less readily controlled by the operator.

(*b*) Trephines driven by electric or hand motors : instruments liable to fail at the critical moment, cumbersome, and certainly more prone to damage meningeal vessels and dura. Further disadvantages will be alluded to in dealing with the formation of the osteoplastic flap (see p. 209).

The enlargement of the trephine hole to the required size and shape. Previous to any enlargement of the trephine hole, the dura mater must

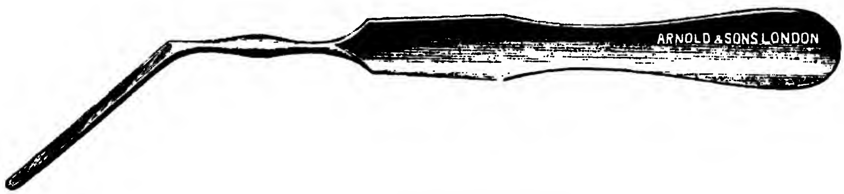


FIG. 109. HORSLEY'S DURAL SEPARATOR.

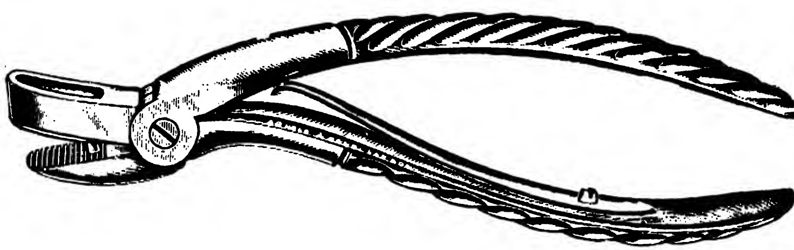


FIG. 110. KEEN-HOFFMANN CRANIECTOMY FORCEPS.

be separated carefully from the overlying bone with the aid of Horsley's or other dural separator (see Fig. 109).

Of the many patterns of craniectomy forceps that have been invented, the following four may be accepted as affording the best types and as sufficing for all operative procedures :—

The Keen-Hoffmann forceps are of great general utility in the enlargement of the gap and are capable of biting away fragments of bone in both thick and thin skulls. The visceral blade is introduced between the dura and the bone and the *morcellement* carried out as required. It is essential that the operator should be content with the removal of small portions of bone at each bite of the instrument. A slight outward leverage aids in the process.

Lane's fulcrum forceps. The advantages of this instrument (see Fig. 111)

are best illustrated by quoting from the *inventor's description*[1]: 'The instrument is seen to consist of two blades moving on one another around a transverse axis. The proximal blade ends in a deeply serrated surface, which rests upon the bone immediately beyond the portion which is to be removed. It acts as a fulcrum around which the forceps move in a vertical plane when the handles are approximated and depressed. The distal blade is claw-shaped, presenting a sharp cutting edge. This is introduced beneath the piece of bone which the surgeon intends to remove, and when the handles are forcibly approximated and depressed this sharp edge tears through the bone with such an amount of power as can be readily understood from the fact that the length of the short arm of the lever, which is one of the first order, corresponds to the varying, though always narrow, interval which exists between

FIG. 111.
LANE'S FULCRUM CRANIECTOMY FORCEPS.

FIG. 112.
HORSLEY'S GOUGE FORCEPS.

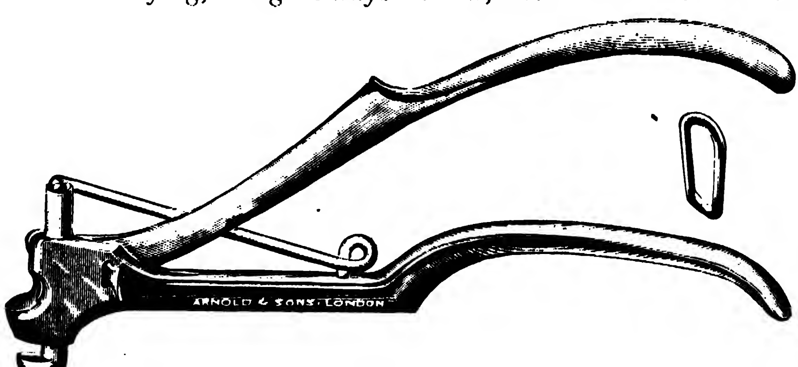


FIG. 113. DE VILBISS'S CRANIECTOMY FORCEPS.

the ends of the two blades when in use, while for all practical purposes the force that can be brought to bear upon the long arm is unlimited.'

[1] *Lancet*, November 10, 1894.

These forceps are eminently suited for the rapid removal of large fragments of bone.

Horsley's gouge or nibbling forceps (see Fig. 112) are mainly utilized in the smoothing and refreshing of the rough edge of bone that is left after the application of either of the above-mentioned forceps. Also of use in *morcellement* of the thinner portions of the skull, *e.g.* the squamous portion of the temporal bone and cerebellar fossa.

De Vilbiss's forceps. The pattern shown in Fig. 113 enables the operator to cut rapidly a narrow channel in the bone. The instrument may be used with advantage in the formation of the osteoplastic flap (see p. 208).

CRANIOTOMY

Craniotomy, or osteoplastic resection of the skull, was carried out first by Wagner.[1] The method has for its main object the formation of a combined flap of scalp and bone, and the exposure of dura and brain to an extent directly proportionate to the size of the bone-flap. The flap receives a good blood-supply, and is capable of ready replacement.

In deciding, however, between craniectomy and craniotomy in any given case, the relative dangers and disadvantages of the two operations must be considered.

The main disadvantages of the osteoplastic flap are as follows:—

(*a*) The attendant shock is often considerable.

(*b*) The formation of the flap, even by skilled hands, is a procedure that requires considerable time—seldom less than half an hour, and, in the presence of complications, often much longer.

(*c*) There is undoubtedly an increased risk of injuring meningeal vessels and dura mater, the former complication possibly necessitating such use of the craniectomy forceps in order to expose fully the bleeding point that the flap loses its main advantage, namely, accurate reposition. In some few cases it has been found necessary to remove the flap altogether.

(*d*) The formation of the flap may merely suffice to expose a part of the tumour or blood-cyst, the craniectomy forceps being again called into requisition.

(*e*) The replacement of the flap occasionally prevents the establishment of adequate drainage, and such a procedure is essential after the discovery of pus, after the removal of large and hæmorrhagic brain-tumours, and after the evacuation of a subdural hæmatoma or an arachnoid cyst.

Many of the above-mentioned disadvantages may be obviated by accurate diagnosis and by skilful operation. Even under the most

[1] 'Die temporäre Resection des Schädeldachs,' *Centralbl. für Chirurgie*, 1889, vol. xvi.

favourable circumstances, however, it must be acknowledged that craniotomy has further restrictions.

It is contra-indicated in most cases of intracranial hæmorrhage. For instance, in middle meningeal hæmorrhage, the formation of an osteoplastic flap gives a needlessly large exposure and adds considerably to the time during which the patient is under the anæsthetic. Furthermore, insomuch as most cases of intracranial hæmorrhage are associated with a fracture, perhaps comminuted, it is quite impossible, under such circumstances, to form a flap of this nature.

It is contra-indicated in those cases of Jacksonian epilepsy which result from deficiency in the bone, from bone depression, and from thickening and matting of membranes. In such cases, craniectomy is to be preferred to craniotomy, the deficiency in the bone being rectified, if necessary, at a later date.

It is contra-indicated in operations conducted for the exposure of the Gasserian ganglion, and for the cerebellum. In both these instances even craniectomy allows but limited exposure, whilst the presence of a craniotomy flap would restrict still further the operative field. The flap method has been practically abandoned for the operations in question. It may be added also that the thin cerebellar walls do not lend themselves readily to the formation of an osteoplastic flap.

It should be stated perhaps that some of these contra-indications are not accepted by many Continental and American surgeons. In this country, however, the use of the osteoplastic flap is more or less restricted to those cases in which a reasonably certain diagnosis can be made that the patient is suffering from a tumour of the cortex or meninges. The method can also be used with advantage in those cases in which, owing to some uncertainty in the diagnosis, it is desirable to expose a large superficial area of the cerebral cortex. If an incorrect diagnosis be made and no tumour found, the flap can be replaced without that resultant deformity which exists necessarily after craniectomy.

Furthermore, even in the event of the discovery of a localized subdural hæmatoma or arachnoid cyst, for both of which conditions drainage is usually required, the flap may be replaced and one of the trephine holes utilized for the emergence of the drainage tube.

The general advantages of the osteoplastic flap are obvious, and if the operation be restricted to suitable cases, and carried out by experienced hands, the results are very satisfactory. This is especially the case when the further manipulation of dura and brain is postponed for a few days (see p. 261).

Operation. The preliminary details of the operation are practically identical, whatever methods be adopted for the division of the bone.

A large ▽-shaped incision is made in such a manner that the three limbs enclose the area which requires exposure. The knife is entered at one extremity and carried down to the bone, and the three incisions rapidly completed one after the other. There is no bleeding worth mentioning if the scalp-tourniquet be used. The incised pericranium is then stripped away from the bone, in a direction away from the centre of the flap, for about half an inch. At the anterior and posterior terminations of the incision, and at the two angles of the flap, the scalp and pericranium are pushed aside so as to allow of the application of a half-inch trephine. At these four points holes are bored and the four disks of bone removed. This trephining must be carried out with all the usual precautions (see p. 199).

The subsequent procedures vary according to the measures adopted for the division of the bone. This may be carried out with Gigli's wire saw, with Doyen's craniotomy saw, with the hammer and chisel, or by means of burrs and saws driven with electricity. Gigli's saw divides the bone from *within outwards*, whilst the reverse is the case with regard to all other methods. It is obvious that, however skilful the operator may be, the cutting of the bone from without inwards increases the risk of causing damage to the underlying structures. Gigli's method therefore presents distinct advantages.

The formation of the bone-flap with Gigli's saw. The dura mater is separated from the bone between the two anterior, the two upper, and the two posterior trephine holes. This is carried out either with Gigli's director or with Horsley's dural separator. Gigli's director (see Fig. 117) is passed between the two upper trephine holes, the handle well depressed and the head kept in contact with the bone. When presenting through the more distal hole, the whalebone guide is passed along the groove of the director, and the special saw (see Fig. 118) attached to the holes at the apex of the guide with a fine silk ligature. The guide is then withdrawn, and the saw after it, until the latter emerges from the two trephine holes and lies, throughout its course, between the director and the bone.

The handles are then affixed to the saw, and the bone divided between the two holes in an oblique manner so that the flap, when replaced, rests on a ledge of bone. The action of the saw generates so much heat that the assistant must be instructed to keep up continuous irrigation; the sawing process itself is carried out by steady side-to-side traction, without jerks. If the saw breaks, a special handle may be attached, thus obviating the necessity of introducing a fresh saw.

The division of the bone is completed between the two upper, between the two anterior, and between the two posterior holes, after which the

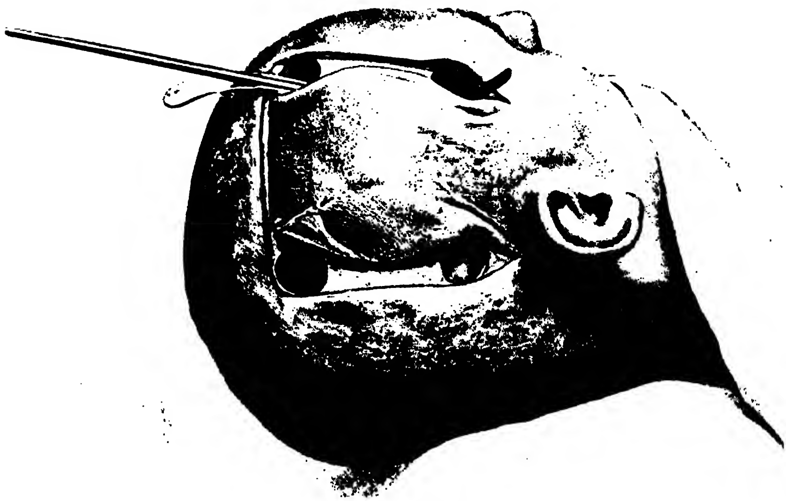


FIG. 114 THE OSTEOPLASTIC FLAP. *First stage.* Shows the four trephine holes and Gigli's director in position.

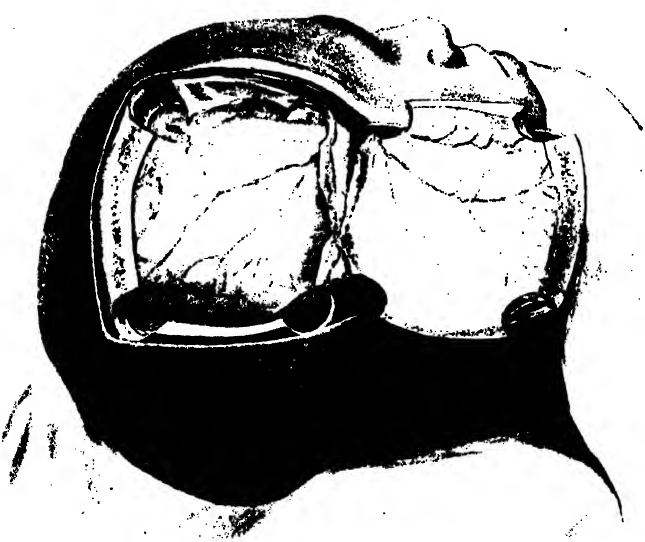


FIG. 115. THE OSTEOPLASTIC FLAP. *Second stage.* Shows the osteoplastic flap turned back and the exposure of the dura mater.

saw is introduced between the two lower holes. In this last case, however, it is only necessary to weaken the bone by the division of the internal table, and, in order to fulfil this object, the saw should be worked in a more horizontal plane. The internal table having been divided, the flap is levered outwards by means of two periosteal elevators introduced beneath the bone-flap at its upper part. The dura is carefully stripped away, and the flap finally broken across at its base by grasping the bone between the fingers and sharply snapping it across. The flap is enveloped in gauze, and held aside till the termination of the operation.

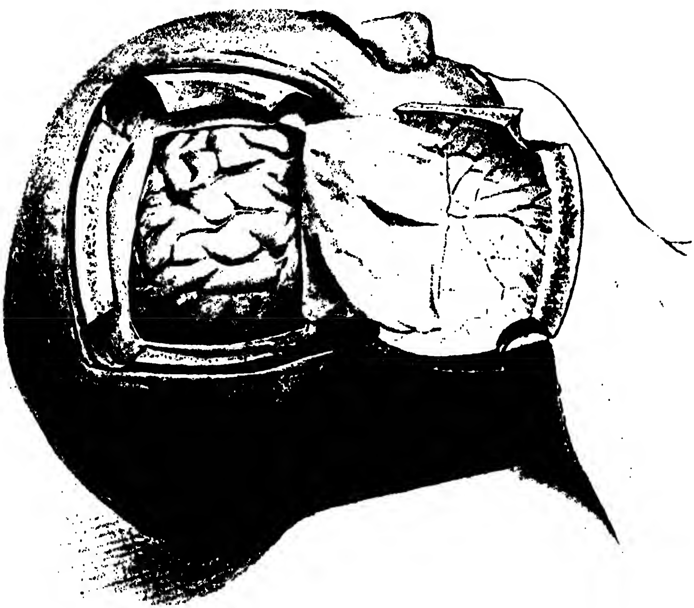


FIG. 116. THE OSTEOPLASTIC FLAP. *Third stage.* Shows the turning back of the dura mater and the exposure of the brain.

The base of the flap should then be examined with the object of seeing whether any of the underlying meningeal arteries have been damaged. Some difficulty may be experienced in stopping the hæmorrhage from such a source, and it may become necessary to strip the dura further away from the bone and utilize the craniectomy forceps before the bleeding point can be secured. In some few cases it has been found necessary to remove the flap altogether. Such a course, however, should very rarely become necessary if due care be exercised in the fracture of the base of the flap.

Time may sometimes be economized by making trephine holes only

at the two upper angles of the flap. These are connected horizontally by Gigli's saw, while the vertical cuts are made with De Vilbiss's forceps (see Fig. 113). At the lower angles of the flap the forceps may be so

FIG. 117. GIGLI'S DIRECTOR AND GUIDE.

manipulated as to round off the corners and weaken the base of the flap. Fracture is readily produced.

The formation of the flap with the aid of the hand-saw, hammer, and chisel. In place of Gigli's saw, the four holes can be united with the hand-saw, preferably with that pattern devised by Doyen (see Fig. 119), in which the depth of the penetrating edge is regulated at will by a graduated guard. The complete division of the whole thickness of the skull by means of the saw alone is conducive to dural injury, and it is therefore advisable to saw through the external table and diploe alone, the final division being completed with the craniotomy chisel (see Fig. 120) and hammer. The projecting arm of the chisel is kept firmly against the overlying bone by firm depression of the handle, the dura being thus separated from the bone and also protected from injury at the same time. With a few taps of the hammer, the inner or vitreous table of the skull is split along the desired line, and the flap turned back as before.

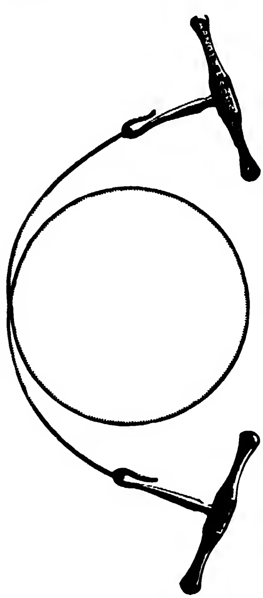


FIG. 118.
GIGLI'S WIRE SAW.

This method possesses no advantages over the one previously described, whilst, on the other hand, there is an undoubted liability to dural and meningeal injury: firstly, because that complication is prone to occur in all methods where the bone section is carried out from without inwards, and secondly, because skulls, even of normal individuals, vary in thickness to an extraordinary degree. Furthermore, the chisel tends to split off small fragments of bone which may possibly tear the dura, and finally, the application of

the hammer must necessarily result in mild concussion and correspondingly add to the shock of the operation.

The formation of the flap with the aid of burrs and saws, driven by an electric motor or other means. Many burrs and saws have been recommended, graduated in size and shape according to the region of the skull which is to be opened. Hartley[1] expresses himself well satisfied with 'a small motor trephine of such size and weight that it can be held by

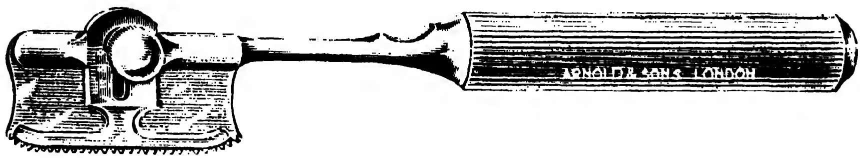


FIG. 119. DOYEN'S GRADUATED SAW.

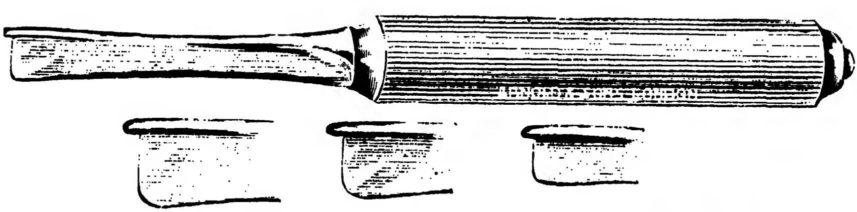


FIG. 120. CRANIOTOMY CHISEL.

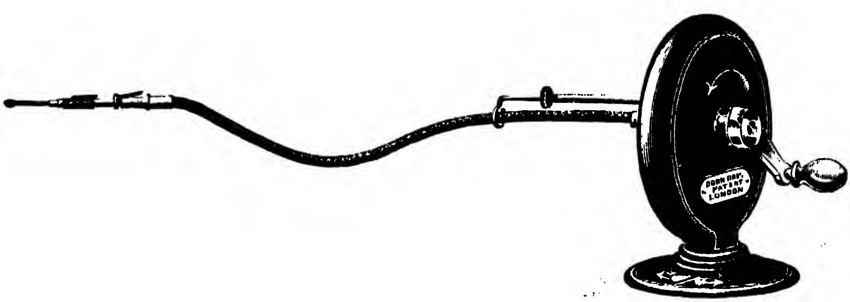


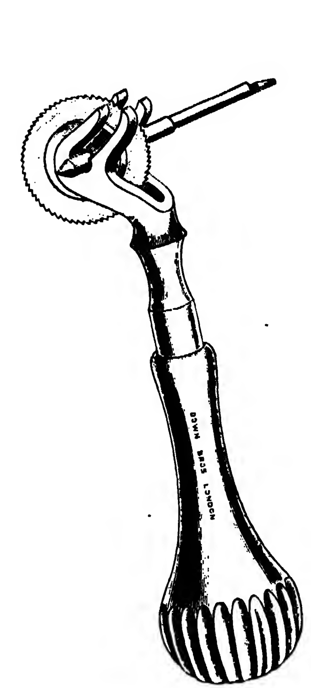
FIG. 121. A HAND-MOTOR. For use with Nicholl's and van Arsdale's saws, drills, &c.

the operator himself and allowing of perfect control, both of the cutting tool and of the power. The tools are connected by means of an appropriate chuck directly to the armature, thus obviating all loss of power when a flexible shaft is used. The trephine holes are cut with the motor trephine, and the guarded saw then introduced, the three sides of the flap being sawn through in such a manner that the final application of the hammer and chisel completes the section of the bone.'

[1] *Annals of Surgery*, 1907, p. 481.

Two instruments received with some favour in this country are Nicholl's guarded saw and van Arsdale's saw. Both of these can be driven by the hand-motor patented by Down Bros. Nicholl's saw is provided with a series of 'guards', graduated according to the depth of bone required to be penetrated. Van Arsdale's saw cuts in circles of 2½ and 3 inches in diameter (see Figs. 121–3).

The disadvantages of the hammer and chisel, and of all electrical devices, are admirably summed up by Harvey Cushing[1] in the following



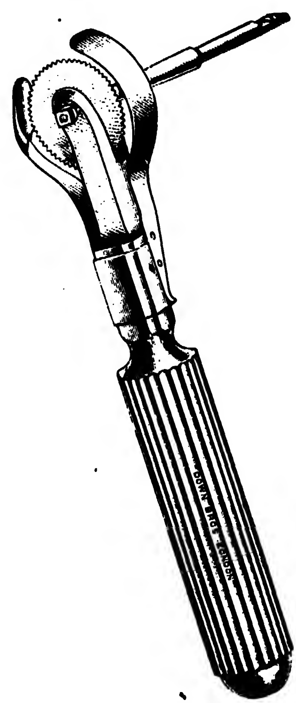


FIG. 122. NICHOLL'S GUARDED SAW. FIG. 123. VAN ARSDALE'S SAW.

words: 'Simplicity is a desirable quality in operative technique, but the blows of a mallet, even though transmitted in a glancing manner, are undesirable; and speed, the chief advantage of the motor-driven rotary tools, is invariably a source of danger. It matters little whether an osteoplastic flap can be elevated by one method in seven minutes, or whether another requires twenty; and an operator who persists in taking dangerous corners at high speed will be the cause of a serious or fatal accident some day, whether he is driving an automobile or opening the skull. For in the more rapid operation, should dura or cortex happen to

[1] *Surgery, Gynæcology, and Obstetrics*, March, 1908.

be injured at the time of making the bone-flap, not only is the chance lessened of a successful result, particularly in cases with increased cerebral tension, but also time is actually lost. It is the hare and the tortoise over again.'

The same authority also writes elsewhere: 'Surgeons who use electro-motive force for osteoplastic operations are able to work very rapidly, and if this does not mean added risk of accident it is desirable. However, having witnessed, twice from a Doyen circular saw, and once from a Crile drill, what I regard as a most serious accident—namely, the division of bone and dura at the same time, owing to the fact that the guide of the speeding instrument worked its way through the adherent membrane instead of separating it from the skull—I have clung to the somewhat slower, but certainly less dangerous operation by hand-driven instruments.'

The experience of the writer leads him to the conclusion that the formation of the osteoplastic flap is carried out with the greatest safety to the patient by means of the hand-trephine, Gigli's saw, and De Vilbiss's forceps.

CHAPTER III

OPERATIONS FOR FRACTURES OF THE SKULL

OPERATIONS FOR FRACTURE OF THE VAULT IN ADULTS

Indications. Fractures of the vault of the skull are often classified arbitrarily into two main groups, according to whether operative treatment is necessary or not, the two groups being differentiated sharply from one another. There is, however, no such line of demarcation, for, though in many cases the correct mode of treatment is obvious, yet there are a considerable number of cases in which great difficulty may be experienced in arriving at a conclusion as to whether an operation is advisable or not.

A general review of the indications for operation will show that the adoption of an expectant policy frequently ends in disaster, and there are, furthermore, but few cases on record in which the surgeon had reason to regret the carrying out of operative measures.

In the event of the general condition of the patient being compatible with operation, such treatment is called for urgently in all the following conditions :—

(*a*) All cases of punctured fracture.

(*b*) All cases of depressed fracture, whether diagnosed by palpation or by inference, whether simple or compound, whether complicated or not.

(*c*) All cases of fracture complicated by extra-dural or localized sub dural extravasation of blood.

(*d*) All elevated fractures.

(*e*) All compound fractures.

In all these instances, both from the presence of depressed fragments of bone and from associated injuries to brain and intracranial vessels, it is obvious that no mere expectant policy should be pursued. The surgeon has also to bear in mind the possible development of meningeal infection and the more remote onset of Jacksonian epilepsy, &c. In other words, early and active surgical treatment is imperatively demanded, for it is not only necessary that every effort should be strained to save the patient's life, but that the surgeon should carry out those procedures which will guard most effectually against the more remote possibilities of the injury.

The advisability of operating on simple and uncomplicated fractures. If it can be determined that the fracture, whether fissured, stellate, or

comminuted, is simple and uncomplicated by any serious intracranial injury, no active surgical treatment is required. The determination of such conditions is, however, always a matter of considerable difficulty and, from the almost constant presence of an overlying hæmatoma, often quite impossible.

In the general estimation of the case, it should be borne in mind that simple uncomplicated fractures of the vault are decidedly rare. For instance, Dwight,[1] in 145 cases of fractured skull that came to autopsy, found only six in which a fissured and localized fracture of the vault was alone present. It may, of course, be argued that simple and uncomplicated fractures of the vault are seldom fatal, and that all post-mortem statistics are fallacious. Experience shows, however, that a force which suffices to fracture the skull almost necessarily results in further injury.

In these doubtful cases, the surgeon is helped greatly in his decision by a general review of the patient's condition, and more especially by the symptoms regarded as exemplifying the clinical conditions of brain concussion, irritation, and compression.

When there is mild 'concussion', a condition associated usually with no macroscopical lesion of the brain, or at the most with some slight contusion, operative treatment is contra-indicated.

When there is severe 'concussion', a condition usually indicating brain-laceration, considerable doubt exists with regard to the advisability of urging operative interference. In general, it may be stated that a persistent subnormal temperature implies such severe intracranial injury, and so severe a state of shock, that operation is most unlikely to improve the patient's condition. On the other hand, when the temperature rises progressively, it may be accepted that the patient is passing from the state of shock to that of reaction, from the stage of concussion to that of compression, that hæmorrhage is taking place within the skull, and that operation is called for.

When there is 'irritation', a condition usually implying cerebral contusion or slight cerebral laceration, operation is again contra-indicated. 'Irritation,' as here alluded to, implies general cerebral irritation, and not that localized trouble which arises from the pressure of depressed fragments of bone, &c.

When there is 'compression', a condition usually associated with depressed fragments of bone or intracranial hæmorrhage, operative measures are urgently called for.

The advisability of operating on fractures that only involve the internal table of the skull. The diagnosis of a fracture limited to the internal table is only possible when symptoms of localized irritation ensue, due either

[1] *Boston City Hospital Reports*, 1894.

to the direct pressure exercised by the depressed fragments of bone on the dura mater or brain, or to the irritation resulting from a torn meningeal artery. In such cases, operation is indicated. Otherwise, no early diagnosis is possible, and the surgeon must adopt an expectant attitude, awaiting the onset of symptoms and seizing the earliest opportunity to remedy the condition.

Operation. *Preliminary measures.* If there should be a wound of the scalp, no attempt should be made to gauge the extent of the injury till the region of the wound has been shaved and cleansed: digital examination enables one to obtain far more certain information as to the extent of the injury than can be obtained by any instrumental means. It is perhaps hardly necessary to add that care must be taken to avoid mistaking one of the sutures of the skull for a fissured fracture.

Exploration having been determined upon, and the usual preparatory treatment carried out, the scalp-tourniquet is applied, and a suitable scalp-flap framed and turned down, advantage being taken in the formation of the flap of any existent scalp injury.

The subsequent details vary according to the nature of the fracture.

Fissured fractures. If, after thorough exposure of the parts, the operator be satisfied that he has to deal with an uncomplicated fissured fracture, the scalp-flap is returned into position, and a small drainage tube inserted at the most dependent part of the flap, this tube being allowed to remain for twenty-four to thirty-six hours.

If, on the other hand, the symptoms point to the presence of an extra-dural hæmorrhage, the bone is trephined where the line of fracture crosses the course of the suspected vessel. In subdural extravasation the trephine is applied over that part of the brain, in the immediate vicinity of the fracture, from which the symptoms appear to emanate.

In a small proportion of cases, the symptoms point to a marked increase in the intracranial pressure without any definite localizing features. Under such circumstances, much can be done to relieve the increased pressure by carrying out the operation of 'cerebral decompression' (see p. 220).

Depressed fractures. The operative details vary according to the nature of the osseous lesion.

(*a*) If the depressed fragments of bone are interlocked in such a manner that simple elevation is impossible (*e.g.* pond and gutter fractures), it will become necessary to trephine in the immediate vicinity of the fracture in order to lessen the mutual attachment of the fragments one to another, and obtain sufficient purchase for their elevation or removal.

The pericranium is stripped away from the region of the depression (see Fig. 124), and a small trephine applied in such a manner that the

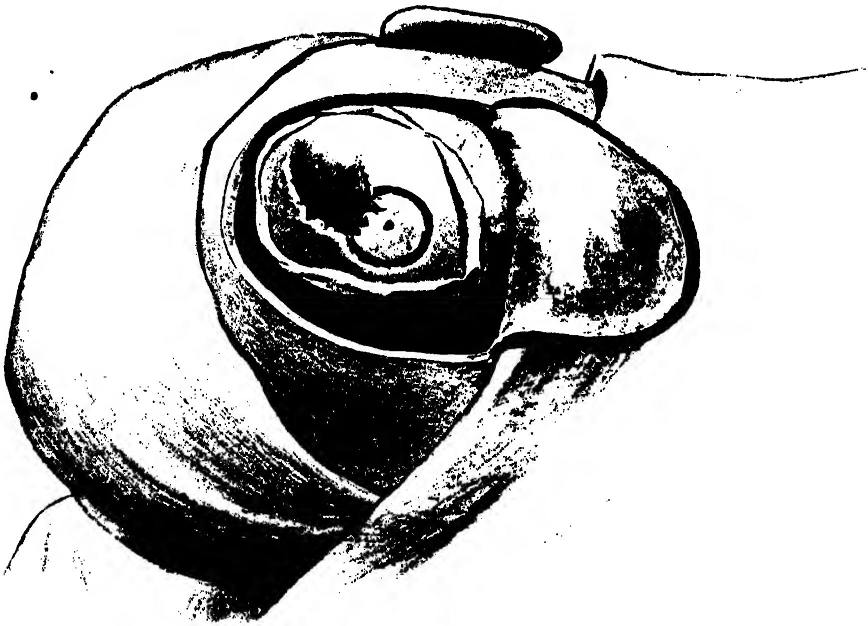


FIG. 124. THE ELEVATION OF A DEPRESSED FRACTURE. *First stage.* The trephine circle includes the outer portion of the depressed area.

FIG. 125. THE ELEVATION OF A DEPRESSED FRACTURE. *Second stage.* The trephine disk has been removed and the elevator is in position.

trephine circle includes the outer part of the depression. Care must be taken to avoid more pressure than is absolutely necessary over the depressed fragments for fear of causing injury to the underlying soft parts. This advice is all the more necessary when it is realized that the fracture of the internal table is almost invariably more extensive than that which involves the external table of the skull.

The disk of bone is removed and the conditions investigated with the dural separator. When the degree of depression and the splintering of the internal table are not excessive, the parts may be elevated into position. In most cases, however, the uncertainty that exists with regard to the possibility of extensive splintering of the internal table, with dural laceration or other lesion, renders it necessary that the depressed fragments should be either elevated and removed, or elevated to such an extent that the dura can be fully investigated. For this purpose, the craniectomy forceps may be needed. The dura can be now examined. If torn, the opening may require enlargement in order that the brain can be brought into view in such a manner that complete investigation can be carried out for any osseous fragments that may have been driven into it ; all such fragments are carefully removed. All hæmorrhage is arrested, the dura mater sewn up, and the scalp-flap approximated, a rubber drainage tube being inserted at the most convenient part.

(*b*) When the depression is of such a nature that the elevation of the fragments can be carried out without preliminary trephining, the fragments are raised with the periosteal elevator, and the membranes and brain examined as described above.

Before turning to the next class of fracture, it will be convenient to allude briefly to the modern teaching with regard to the replacement of osseous fragments and trephine disk.

In simple fractures, the disk and larger fragments of loose bone are to be replaced in the anticipation that they will live entire, in part, or will act as a scaffolding medium for the formation of dense fibrous tissue. After removal from the wound, and during the completion of the operation, the vitality of all loose fragments may be preserved by placing them in hot saline solution.

In compound fractures, the smaller fragments are discarded, whilst the trephine disk and larger fragments of bone may be boiled and then replaced. It must, however, be clearly understood that all replaced fragments of bone act as sequestra unless primary union of the wound can be assured. The question of replacement depends, therefore, to a large extent on the nature of the wound. In all septic cases it is necessary to discard all loose fragments, merely preserving those that retain their pericranial attachment. The gap in the vault may be remedied at a later date by one or

other of the methods advocated for the closure or protection of defects in the skull (see p. 245).

Punctured fractures. In this class of fracture there is a special liability to dural laceration and in-driving of comminuted fragments of bone. A full exposure of the parts is therefore essential. The trephine can be applied in the immediate vicinity of the fracture, or, as is often preferable, the site of puncture may be enclosed in the circle resulting from the use of a large-sized trephine. After removal of the bone, the craniectomy forceps may be required to afford complete exposure of the dura mater. The site of dural puncture is enlarged with the blunt-pointed scissors, the brain examined, and all loose particles of bone removed. The dura should be sewn up as well as circumstances permit, and the wound drained as alluded to in the previous section.

Fractures limited to the external table. Fractures limited to the external table usually result from the impact of glancing bullets, and, in the absence of symptoms pointing to the existence of intracranial complications, it is merely necessary that a suitable scalp-flap should be framed, turned down, and all comminuted fragments of bone, dirt, and foreign bodies removed. The 'gutter' in the bone is examined, the ragged edges repaired with a gouge or Volkmann's spoon, and the wound lightly plugged and drained.

Fractures limited to the internal table. As previously indicated, the diagnosis of this condition is only practicable when the depression of osseous fragments, &c., so irritate the dura mater and brain that localizing symptoms ensue. For instance, epileptic fits of a Jacksonian type may develop shortly after the accident, this condition demanding a full exposure of the affected region. The operations necessary for the treatment of traumatic epilepsy and insanity are dealt with in Chapter VI.

OPERATIONS FOR FRACTURE OF THE BASE OF THE SKULL

Indications. Fracture of the base of the skull is not fatal in itself, death occurring from one or other of the intracranial complications incident to the fracture—hæmorrhage, brain laceration, &c. The operative treatment of fracture of the base of the skull comprises, therefore, those measures indicated for the relief of the particular complication present. For each and all of these reference must be made to other sections.

In the absence of all localizing features, benefit may often be derived by the adoption of those operative procedures that aim at the reduction of an increased intracranial pressure ('decompression' operations).

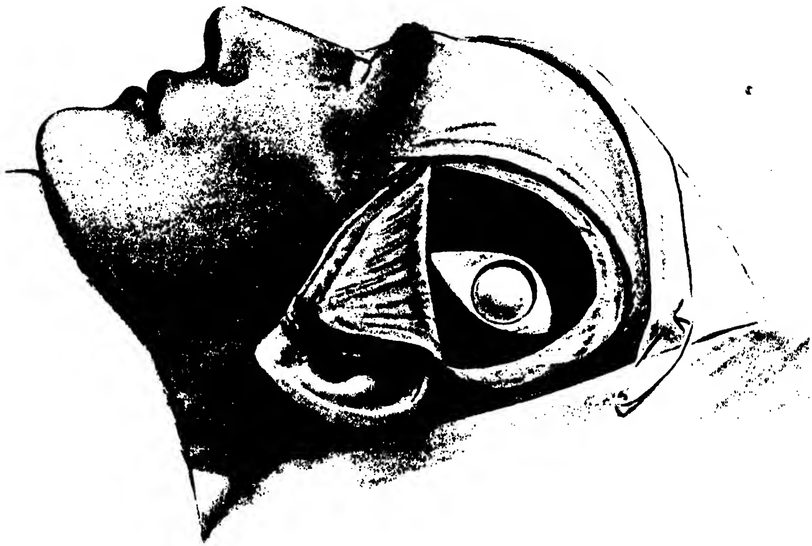


FIG. 126. THE 'INTERMUSCULO-TEMPORAL OPERATION' OF CUSHING. *First stage.* The skin and temporal fascia have been turned down as separate flaps, and the temporal muscle has been split in the direction of its fibres. The exposed bone has been trephined.

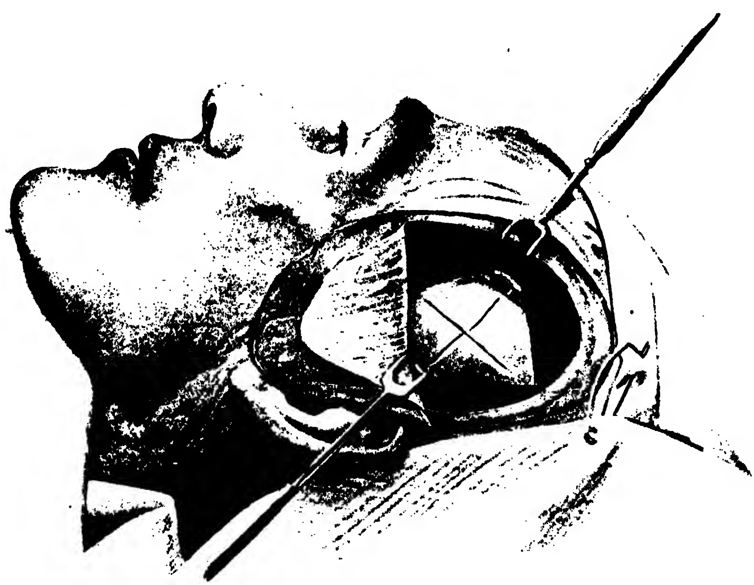


FIG. 127. THE 'INTERMUSCULO-TEMPORAL OPERATION' OF CUSHING. *Second stage.* The fibres of the temporal muscle are widely retracted, and the underlying bone has been freely removed. The bulging dura mater is incised crucially.

Such 'decompression' operations are urgently called for when the raised temperature, slow full pulse, stertorous respiration, and flaccid extremities point to a condition of brain-compression.

'Decompression' operations may be carried out either in the cerebellar region or over the temporo-sphenoidal lobe, one of the so-called 'silent areas' of the brain. The operations are known as 'cerebellar' and 'temporal decompression' respectively.

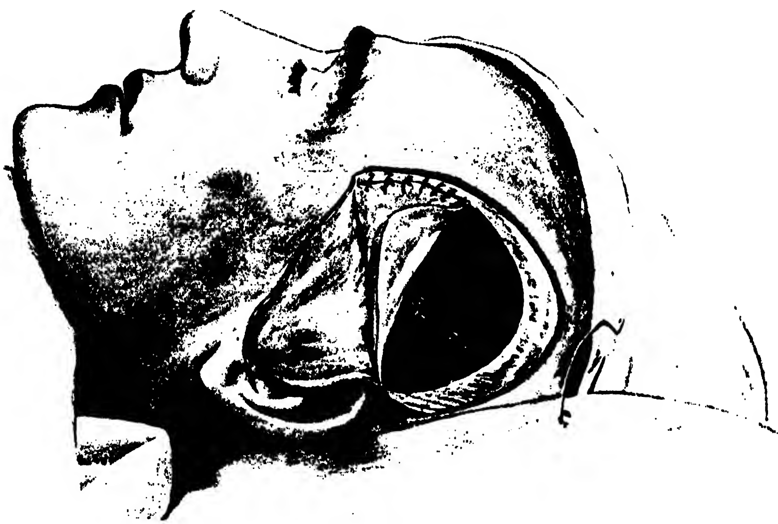


FIG. 128. THE 'INTERMUSCULO-TEMPORAL OPERATION' OF CUSHING. *Third stage.* The split temporal muscle is reunited and the temporal fascia is partly sewn into position. Note the fringe of temporal fascia attached to the upper temporal crest.

The writer has had considerable experience of both operations, and though, theoretically, the cerebellar operation should bring about the greatest benefit to the patient, insomuch as the exposure is carried out in the immediate neighbourhood of the medullary centres, and though the immediate results of the operation may be satisfactory, yet the fact remains that but very few lives are saved by adopting such measures.

On the other hand, the advantages of the operation described by Harvey Cushing as 'intermusculo-temporal cerebral decompression' are very great. They have been summarized by Cushing as follows :—

(*a*) The frequency with which the bony lesion occurs in the middle fossa of the skull.

(*b*) The fact that cerebral contusions are especially liable to involve the tip of the temporo-sphenoidal lobe.

(*c*) The exposure of the territory of the middle meningeal artery, and the ease of determining the presence of an extra-dural hæmorrhage.

(*d*) The possibility of draining through a split muscle rather than through the scalp.

(*e*) The subsequent protective action of the muscle in case a hernia tends to form in consequence of traumatic œdema.

(*f*) The subsequent absence of deformity, the skin incision being carried out in the main through the hairy portion of the scalp.

Operation (the intermusculo-temporal operation of Cushing). After the application of the scalp-tourniquet, an incision is made which starts immediately posterior to and below the external angular frontal process, and passes upwards and backwards along the line of the temporal crest to curve down finally to a point just above the ear. The incision involves the skin and subcutaneous tissues only, and the flap, including the superficial temporal vessels, is turned down to its base. Great care must be taken to avoid cutting the temporal artery at the base of the flap. The exposed temporal fascia and muscle are then divided down to the bone by an incision which corresponds in direction to the line of the temporal muscle fibres, and which passes, obliquely downwards and forwards, from the central point of the temporal crest to the mid-point of the zygoma. In the region immediately above the zygoma, this division of muscle fibres is carried out preferably by forcible retraction. Troublesome hæmorrhage is thereby often prevented. All bleeding points are secured. The muscle fibres are then stripped, both forwards and backwards, from the bones entering into the formation of the temporal fossa, care being taken to avoid detachment of the muscle from the temporal crest itself. The pin of the trephine is placed over the angle between the anterior and posterior branches of the middle meningeal artery, and the disk of bone removed. The dura is separated from the overlying bone, the craniectomy forceps applied, and the bone entering into the formation of the temporal fossa freely cut away. The removal of bone should be carried out mainly in the anterior and posterior directions. The bulging dura is incised crucially, right up to the margins of the osseous gap, all meningeal vessels that cross the line of dural section being previously ligatured on either side of the proposed line of dural section. The anterior part of the temporo-sphenoidal lobe is exposed, and, by gentle retraction, a small rubber drainage tube may be inserted along the floor of the middle fossa of the skull.

The drainage tube is brought out through the dura (which membrane is not sewn up) and through the split fibres of the temporal muscle, these

being otherwise carefully approximated. The scalp-flap is sewn into position with silk or salmon-gut sutures, a hole being cut for the exit of the tube. Drainage should be maintained for at least twenty-four hours, and longer, if necessary.

As a slight modification of Cushing's operation, the writer has found that certain advantages can be obtained if the temporal fascia be turned down as a separate flap, a fringe being carefully retained along the temporal crest to aid in the later approximation of the fascia. If this proceeding be carried out, a greater area of bone can be removed, a matter of considerable importance when it is considered that the relief of intracranial pressure is directly proportional to the size of the gap in the skull and the extent of the dural incision.

After the union of the temporal muscle, the fascia is united, if possible, to the fringe that has been preserved in the region of the temporal crest. This modification is depicted in Figs. 126-8.

OPERATIONS FOR FRACTURE OF THE VAULT AND BASE OF THE SKULL IN CHILDREN

Indications. The marvellous vitality and recuperative power of the infant justify the surgeon in adopting a more expectant policy than that indicated for similar conditions in adults. Otherwise, the indications for operation closely resemble those previously alluded to in dealing with fractures of the skull in adults.

Birth-fractures. Under this heading are included those fractures which result from birth-injury and those also which occur shortly after birth, from whatsoever cause.

Both fissured and depressed fractures are seen, and are alike usually more or less obscured by the presence of an overlying hæmatoma.

Simple uncomplicated fissured fractures require no surgical interference, but when the fracture is associated with symptoms indicative of intracranial hæmorrhage, the ordinary treatment, as laid down in the preceding sections, must be carried out. Babies are also liable to a special variety of subdural extravasation, a condition known as 'birth-hæmorrhage', to which allusion is made on p. 232.

With regard to depressed fractures, much difference of opinion exists as to the requisite treatment. Some surgeons maintain that the depression will rectify itself in the course of time, whilst others urge that evidence is gradually accumulating that such favourable results are rather the exception than the rule, and that the depression usually persists as a permanent defect, retarding the development of the underlying cortical substance.

In the absence of symptoms pointing either to general or local irritation the depression may be allowed two weeks in which to rectify itself, and failing any improvement in the local conditions the surgeon must consider the advisability of remedying the defect.

The operative treatment of depressed fractures. After every precaution has been taken to lessen the shock which will accompany and follow the operation, a scalp-flap is turned down which will suffice to expose the depressed area of bone. The trephine ($\frac{1}{2}$ inch diameter) is then applied in such a manner that the trephine circle includes the outermost margin of the depressed region. After removal of the disk, the dura mater is gently separated from the under aspect of the bone and the depressed region elevated outwards with the aid of the periosteal elevator, the apex of the instrument being applied to the apex of the depression. The bone usually springs back readily, and in such cases the trephine disk can be replaced and the wound sewn up.

In some cases, however, the defect cannot be remedied in this manner, the depression recurring as soon as the outward leverage is removed. It has therefore been recommended that the depressed region should be completely cut out with a large trephine, inverted on a swab or sterilized towel, reduced to the required curvature, and then replaced in such a position that the internal surface finally becomes external.

Nicholl[1] reports twenty-three cases in which operation was carried out for depressed birth-fractures with the following results :—

(*a*) In ten cases the depression was merely levered back into position. All these cases ultimately gave disappointing results on account of recurrence of the deformity.

(*b*) In thirteen cases trephining and inversion were carried out. In all these the ultimate result was most satisfactory, osseous union being apparent after ten days.

[1] *Annals of Surgery*, December, 1904.

CHAPTER IV

OPERATIONS FOR INTRACRANIAL HÆMORRHAGE

OPERATIONS FOR HÆMORRHAGE FROM THE MIDDLE MENINGEAL ARTERY

Indications. Operative interference is indicated in all cases of hæmorrhage from the middle meningeal artery if the condition of the patient be compatible with such treatment. The earlier the operation is carried out the better.

Operation. **For hæmorrhage from the anterior branch.** After the usual preparatory treatment, the 'site of election' for trephining is marked out on the scalp by taking a point which lies 2 inches posterior to the external angular frontal process and the same distance above the zygoma. A bradawl is introduced through the scalp so as to indent the external table of the skull, thus aiding in the subsequent application of the trephine. This procedure cannot be carried out if the hæmorrhage be associated with a depressed or comminuted fracture in the temporal region. Under these circumstances the affected region is exposed merely by the formation of a suitable scalp-flap.

An incision is made which starts immediately posterior to the external angular frontal process, curves upwards and backwards along the temporal crest, and terminates above the ear. The flap, comprising skin, temporal fascia, and muscle, is turned down to its base, and all bleeding points secured. The scalp-tourniquet is seldom applicable to this condition, and consequently the hæmorrhage is often profuse.

The subsequent procedures vary according to the condition of the bone.

If there be no fracture of the temporal region, the pin of the trephine is placed over the indented spot and the disk of bone removed. Although the presence of an extra-dural clot would minimize the danger of dural injury, yet the trephining must be carried out with all the usual precautions. In the event of an error in diagnosis the surgeon merely adds further complication to the case if either middle meningeal artery or dura be injured, valuable time being lost in the rectification of the trouble.

After the removal of the disk of bone the clot will be exposed, but, in order to obtain more ample exposure, the gap must be enlarged with

the craniectomy forceps, this enlargement being carried out in a direction corresponding to the general course of the vessel, that is, upwards and downwards (see Figs. 129, 130).

If a fissured fracture be found, the bone is trephined where the fracture crosses the line of the artery.

When the fracture is comminuted, the fragments of bone are either levered outwards or removed till sufficient room has been obtained.

FIG. 129. EXPOSURE OF THE BRANCHES OF THE MIDDLE MENINGEAL ARTERY. *First stage.* Suitable scalp-flaps have been turned down, and the skull has been trephined over the 'sites of election' for exposure of both anterior and posterior branches.

The greater part of the clot can be removed either with a Volkmann's spoon or ordinary teaspoon, aided by free irrigation with hot saline solution.

Bleeding points should either be seized with forceps and tied with fine catgut, or underrun, with a fully-curved needle threaded with catgut, on either side of the actual site of arterial laceration. The needle must be passed so as to avoid injury to the pia-arachnoid, and, as the vessel is embedded merely in the outer wall of the dura mater, it is not even

necessary that the whole thickness of the dura should be penetrated with the needle.

When the artery is injured above the level of the gap in the skull, the bone is nibbled away in the upward direction till the bleeding point is exposed. Hæmorrhage is then controlled in the manner described above.

When the blood wells up from below, the craniectomy forceps are again called into requisition, and the bone cut away rapidly towards the base

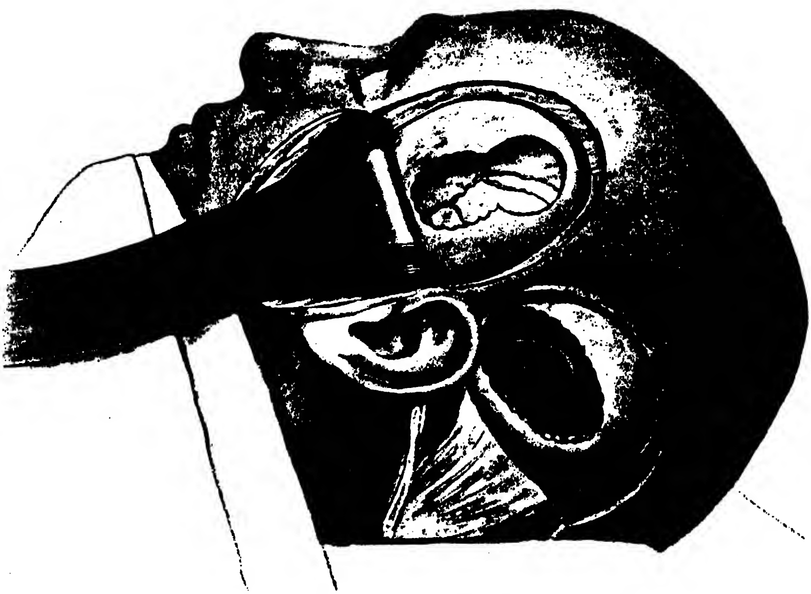


FIG. 130. EXPOSURE OF THE BRANCHES OF THE MIDDLE MENINGEAL ARTERY. *Second stage.* The trephine holes have been enlarged with the craniectomy forceps in the required directions.

of the skull. In the more serious cases, it may be necessary to remove the greater portion of the bone entering into the formation of the temporal fossa. In the meantime, the bleeding may be controlled by plugging towards the base of the skull with narrow strips of gauze. Sufficient bone having been removed, the gauze is withdrawn, when smart sponging should enable the operator to determine the source of the hæmorrhage. At this stage of the operation a head-lamp will be found useful. After the exposure of the bleeding point, the following measures can be adopted whereby to arrest the hæmorrhage:—

(*a*) The application of a ligature on either side of the site of arterial injury.

(*b*) The vessel may be underrun on either side of the injured part.

(*c*) The vessel may be seized with artery forceps and twisted.

(*d*) The hæmorrhage may be arrested by means of gauze plugging.

(*e*) The foramen spinosum may be occluded.

(*f*) The common or external carotid arteries may be ligatured.

Every effort should be made to control the hæmorrhage by ligature, underrunning, or torsion. Such measures are often difficult to accomplish and the surgeon must then have recourse to one of the other methods applicable to the case. Gauze plugs can be relied upon usually to stop the bleeding, but they possess one great disadvantage—they exercise pressure on the cortex and prevent expansion of the brain. The occlusion of the foramen spinosum and the ligature of the common or external carotid arteries complicate and prolong the operation.

The foramen spinosum is exposed in the following manner: The dura mater is rapidly stripped up from the base of the skull, the soft parts gently but firmly retracted, and the foramen identified. Its occlusion may then be effected either by means of a sterilized wooden match, by a small piece of bone derived from those osseous fragments which have been removed during the enlargement of the trephine hole, or by a stout piece of catgut well driven into the hole.

It is open to doubt whether ligature of the common or external carotid arteries is ever necessary, though several cases have been recorded in which such a course was adopted. The external carotid should be tied in preference to the common vessel, since, the brain being already compressed, further interference with the blood-supply will necessarily increase the risk of cerebral œdema and softening.

The hæmorrhage having been arrested, the cavity is thoroughly flushed out with hot water and drained. A small rubber drainage tube will often suffice, though, in the more serious cases and especially when the hæmorrhage has been arrested by means of gauze tampons, the cavity should be plugged lightly with gauze. The proximal ends of the gauze strips are brought out through the most convenient part of the scalp-flap. These drains are allowed to remain for twenty-four to thirty-six hours, at the end of which time they may be shortened or removed according to the circumstances of the case.

Alternative measure for the exposure of the anterior branch of the middle meningeal artery. By some surgeons it is advocated that the artery should be exposed by the formation of an osteoplastic flap (see p. 203). The disadvantages of such a method may be classified as follows:—

(*a*) Rapidity of operation is essential, both for the relief of pressure

and for the control of the bleeding. Valuable time is lost in the formation of the flap.

(*b*) The bleeding is usually associated with a fissured or comminuted fracture of the bones of the temporal fossa ; under such circumstances the flap cannot be formed.

(*c*) An osteoplastic flap restricts the operative field, this being especially the case when the source of the hæmorrhage is situated low down in the middle fossa of the skull.

(*d*) An incorrect diagnosis as to the site of the hæmorrhage may be made, thus necessitating the further enlargement of the gap in the skull, and possibly the removal of the entire bone-flap.

By other surgeons, it has been recommended that the clot should be exposed by means of the intermusculo-temporal operation of Cushing (see Fig. 220). This course is ideal, but unfortunately, from the limitation of the operative field, seldom practicable. The exposure of the clot may, however, be carried out through the fibres of the temporal muscle when the injury has been inflicted below the level of the temporal crest, when the clot is small in extent, and when the case is seen shortly after the accident.

For hæmorrhage from the posterior branch. The 'site of election' for exposure of the posterior branch of the middle meningeal artery corresponds to the point of intersection of the two following lines :—

(1) A line drawn backwards from the upper border of the orbit parallel to Reid's base-line (see p. 187).

(2) A line drawn vertically upwards from the posterior border of the mastoid process of the temporal bone.

The skull is trephined at this point, and the gap in the skull enlarged with the craniectomy forceps in the forward and backward directions (see Fig. 130). The bleeding is arrested after the methods enumerated in the section dealing with hæmorrhage from the anterior branch of the artery.

Results. The ultimate result of operation for middle meningeal hæmorrhage depends on two factors—the time at which the operation is carried out, and the presence or absence of brain contusion and laceration. There is every reason to believe that, when treated early and when unassociated with brain injury, the prognosis, both immediate and remote, is entirely satisfactory.

Wiesman[1] collected 257 cases, of which 110 were submitted to operation, with a mortality of 27 %. Of the cases in which no operation was performed 88 % died.

[1] *V. Bergmann's System of Surgery*, vol. i.

Duchaîne[1] reports 27 cases in which operation was carried out, with death in 6 cases only, a mortality of 22%. No operation was carried out in 7 cases, and all but one died.

Von Bergmann[2] collected 110 cases treated by operation, with 74 recoveries and 36 deaths, a mortality of 32·27%.

These statistics are most instructive, pointing to the urgent necessity of early operation in every suitable case.

OPERATIONS FOR HÆMORRHAGE FROM THE SUPERIOR LONGITUDINAL SINUS

Wounds of the superior longitudinal sinus are almost invariably associated with comminution and depression of the overlying vault, the sinus-wall being perforated, perhaps transfixed, by one or more of the osseous fragments. The blood tends to escape externally along the line of least resistance, but, in the event of interlocking of fragments, or as the result of application of firm pressure, hæmorrhage takes place into both extra-dural and subdural spaces. Extra-dural extravasation is seldom excessive on account of the adherence of the dura to the bone and the low venous pressure. The subdural space, on the other hand, permits of extensive hæmorrhage, on one or both sides of the falx cerebri. The operative measures may therefore be considered under two headings:

(*a*) For injury to the parietal wall with external hæmorrhage.

(*b*) For injury to the visceral wall with subdural hæmorrhage.

Operations for injury to the parietal wall with external hæmorrhage. After the application of the scalp-tourniquet, a flap is turned down, comprising the whole thickness of the scalp and so framed as to receive the best possible blood-supply. Advantage should be taken of any existent scalp injury.

The fracture being in this manner fully exposed, all depressed fragments of bone (excepting such as appear to be embedded in the sinus-wall, which for the time being are allowed to remain) are elevated and removed. Complete exposure of the sinus is required, both in front and behind the actual site of injury, for which purpose the craniectomy forceps should be utilized. If the hæmorrhage be copious it may be arrested by the insertion of strips of gauze between the bone and the dura, in such a way as to obliterate the lumen of the sinus. When all bleeding is controlled, any fragments of bone that project into the sinus may be withdrawn. The rent in the wall should be treated after one of the following methods:—

[1] *Ruptures de l'artère méningée moyenne*, Paris, 1890.

[2] *System of Surgery*, vol. i.

(*a*) It may be possible to sew up the rent with fine catgut. If feasible, this method should always be adopted.

(*b*) The dura may be drawn across from side to side by means of two or three Lembert's sutures introduced in the following manner: A small fully-curved needle, threaded with catgut, is passed through the dura immediately to one side of the sinus, drawn across the site of laceration, and again passed through the dura on the opposite side. The sutures do not penetrate the sinus-wall, and, when tightened up, the lumen of the sinus is practically obliterated. Lateral incisions through the dura, for relief of tension, may be required.

(*c*) The sinus may be ligatured in the following manner: Incisions, $\frac{1}{2}$ inch long, are made through the dura mater, parallel to the line of the sinus and on either side of the rent in the vessel-wall. An aneurysm needle is passed through the falx cerebri and around the sinus, entering and emerging at the dural incisions. The needle is threaded with catgut and withdrawn. Ligatures can be applied in this manner both in front of and behind the site of sinus laceration.

(*d*) In the event of failure to arrest the hæmorrhage by any of the methods mentioned above, the hæmorrhage can be controlled by the insertion of gauze plugs between the bone and the sinus. These plugs should be allowed to remain for twenty-four to thirty-six hours, after which time the wound should be lightly repacked.

Operation for injury to the visceral wall with subdural extravasation. It is usually impossible to remove all the subdural clot, but much can be done to remedy the condition. The dural tension, the absence of pulsation, and the peculiar plum-colour transmitted to the dura by subdural hæmorrhage, not only point to the nature of the trouble, but also enable the surgeon to determine on which side of the falx cerebri the hæmorrhage is situated.

Free drainage must be established, and it is necessary, therefore, that a counter-incision should be made through the dura at the most dependent point possible. A suitable region may present if the bone be extensively comminuted. Otherwise, a narrow channel must be cut in the bone with the craniectomy forceps, prolonged in the downward direction till the lower limit of the clot is reached (see Fig. 131). In carrying out this procedure, it may become necessary to extend the scalp incision.

The presenting clot is then removed, partly with the spoon and partly by irrigation. Irrigation may be carried out with advantage from the site of primary dural injury to the counter-incision below.

In the more favourable cases, both dural incisions may be closed up, but in the majority of cases it is advisable to establish drainage, a rubber drainage tube being inserted in the manner shown in Fig. 132.

OPERATIONS FOR TRAUMATIC SUBDURAL HÆMATOMA OR HÆMATOCELE

It is probable that the hæmatoma forms a short time after the accident, but the symptoms resulting, both of general increase in intracranial pressure and of local brain compression, seldom become marked before

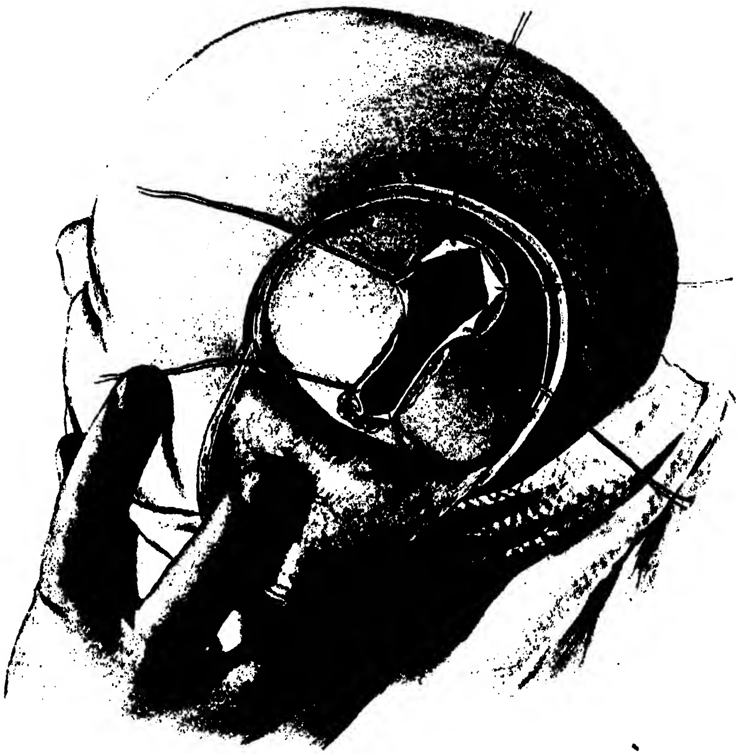


FIG. 131. THE OPERATIVE TREATMENT OF SUBDURAL HÆMORRHAGE. *First stage.* The skull has been trephined over the upper part of the clot and the bone cut away in the downward direction in order to reach the lower limits thereof. The dura mater has been incised, crucially in the upper part and vertically in the lower part.

ten days have elapsed from the time of the accident. Subdural hæmatoceles usually occur over that part of the brain which lies in relation to the fissure of Rolando. Definite localizing symptoms are consequently generally apparent.

The hæmatoma may be exposed either by craniectomy or craniotomy. The former operation is less dangerous to the patient and allows of sufficient exposure to remove the clot.

Operation. The site of trephining having been determined, and the scalp-tourniquet applied, a bradawl is introduced through the scalp so as to indent the external table of the skull and allow of the subsequent accurate application of the trephine. A scalp-flap, suited to the occasion, is turned down, the skull trephined, and the disk of bone removed. The appearance of the dura mater enables the operator to verify the diagnosis.

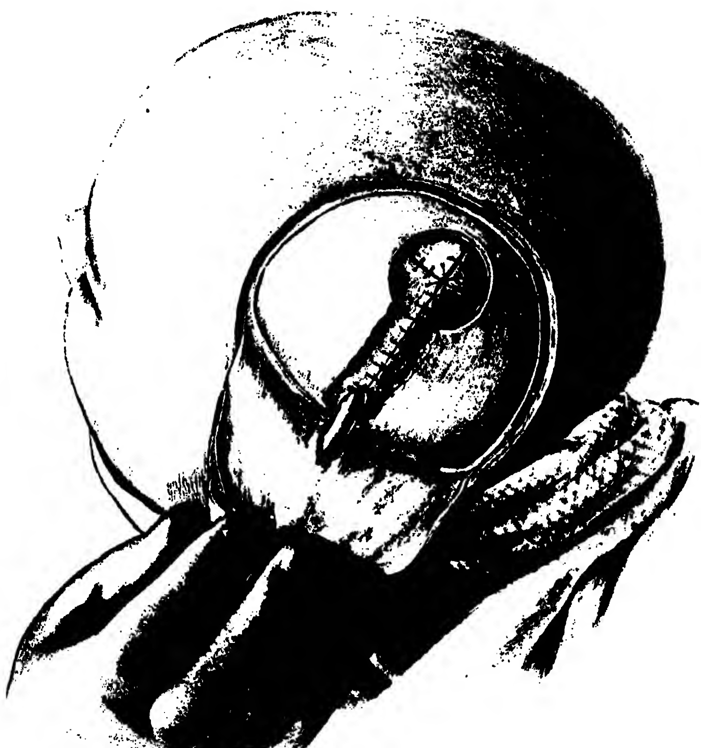


FIG. 132. THE OPERATIVE TREATMENT OF SUBDURAL HÆMORRHAGE. *Second stage.* The clot has been removed and the dura mater sewn up. A drainage tube has been inserted so as to drain the subdural region through the lower part of the scalp-flap.

The bone is then nibbled away in the downward direction towards the lower limit of the clot, the scalp incision being prolonged in the same direction if necessary. In the region of the trephine hole the dura is incised in a crucial manner, and the four flaps held aside by means of catgut sutures passed through the apex of each flap. A blunt director is inserted beneath the dura, passed in the downward direction, and the membrane slit up to within a short distance of the lower margin of the osseous gap. Full retraction of the dura will allow of the exposure of

the clot. Its removal can be carried out by means of the scoop and by irrigation. The cut margins of the dura are approximated above by the cross union of the four apical sutures, and by the insertion of supplementary sutures applied where necessary. The downward prolongation of the dural incision is also sewn up, except at the most dependent point where a rubber drainage tube is inserted beneath the dura mater, and brought out through the scalp-flap (see Fig. 132). This tube must be allowed to remain for at least thirty-six hours.

Results. The most complete results of operative treatment for subdural hæmatoma are supplied by Bowen,[1] who, in a series of seventy-two cases, classifies the cases as follows :—

Class A. Subdural hæmorrhage, apparently without other serious brain injury.

36 cases. 22 recovered after operation.
14 died—11 without, and 3 after, operation.

Class B. Subdural hæmorrhage with serious brain injury.

36 cases. 6 recovered after operation.
30 died—10 without, and 20 after, operation.

In other words, every case died in which operation was not carried out, whilst, after operation, 28 recovered and 23 died.

OPERATIONS FOR PIAL AND ARACHNOID HÆMORRHAGE

The anatomical situation of the extravasated blood prohibits all attempt at direct removal. Much can be done, however, to relieve symptoms of 'compression'. For 'decompression' operations, reference should be made to the preceding chapter.

OPERATIONS FOR INTRACRANIAL HÆMORRHAGE IN THE NEW-BORN

The superficial cerebral veins, in their upward course towards the superior longitudinal venous sinus, occupy the fissures of the brain and are correspondingly protected from injury. In order, however, to enter the lateral lacunæ of the sinus the veins must necessarily leave their cerebral beds and enter upon a short but comparatively unprotected course, and, as a result of the overlapping of the parietal bones, it is in this part of their course that the vessels are liable to laceration. The resultant hæmorrhage is consequently subdural in position and takes place on one or on both sides of the falx cerebri. The clot varies in extent, but is more commonly situated immediately anterior to the fissure of Rolando, overlying that portion of the cortex which is responsible

[1] 'Traumatic Subdural Hæmorrhage,' *Guy's Hosp. Rep.*, vol. lix.

for the movements of the lower extremity of the opposite side. The symptoms of brain compression are associated consequently with symptoms of local irritation. The child may recover, but the effects on the underlying cortex are disastrous.

The age of the patient must not be allowed to weigh in the balance against operative interference, for, if due precautions are taken, the new-born child stands operation well. Cushing[1] also points out that 'the possibilities of surgical relief are limited to the first week or two after the hæmorrhage has occurred, for old cortical scars can neither be helped by medicine nor by the scalpel'.

The clot can be exposed by craniectomy or craniotomy. The latter operation results in a more complete exposure of the clot, but the shock is undoubtedly more severe.

Operation. Exposure by craniectomy is carried out in a manner similar to that previously described for 'traumatic subdural hæmatocele' (see p. 230). The operation should be carried out with the utmost expedition, and every precaution must be taken to avoid shock.

Exposure by craniotomy, advocated by Cushing, is carried out as follows: 'An omega-shaped incision just within the outer margin of the parietal bone is carried down to the bone through the scalp and pericranium, and the latter is scraped away so as to expose the thin serrated edge of the parietal bone. Under this a blunt dissector is passed, so that the edge of the bone is tilted up, and then, with a proper cutting instrument (strong blunt-pointed scissors suffice), the bone is incised in a line conforming with the skin incision 1 centimetre or more within the parietal margin. The parietal bone is then broken across at its base. The dura is opened by a curved incision some distance within the bony margin, and the superficial clot broken away and lifted off in fragments or irrigated away with a gentle stream of warm salt solution. The dura should be accurately sutured, the bone replaced, and the skin closed with suture.'

Results. Cushing reports nine cases with four recoveries, apparently complete and permanent. In the fatal cases there was an extensive extravasation over the entire hemisphere. In three cases a bilateral exposure was required.

[1] *Keen's Surgery*, vol. iii, p. 99.

CHAPTER V

OPERATIONS FOR BULLET-WOUNDS OF THE SKULL AND BRAIN

Indications. Complete reports from the surgeons engaged in the treatment of the wounded in the Russo-Japanese War are not yet to hand, but there is every reason to believe that the experience gained in that war will confirm the indications for operation in bullet-wounds of the skull and brain as laid down by the surgeons in charge of the field-hospitals in South Africa.

The opinions of those civil surgeons who, in this country, have gained considerable experience in such injuries, coincides with the expressed views of those surgeons whose work has been carried out in active service.

For instance, Lawford Knaggs[1] writes: 'There will be always a certain proportion of patients, and that not a small one, which obviously have so short a time to live that to attempt any operative measures would be inhuman. But when these are eliminated it can only be a very exceptional case in which it will not be the surgeon's duty to interfere.' So speaks the civil surgeon.

The surgeons of military experience are even more urgent in their advice. Makins[2] writes: 'The treatment of fractures of the skull possesses a degree of interest that attaches to no other class of gunshot injury, since operative interference is necessary in every case in which recovery be judged possible. The injuries are, without exception, of the nature of punctured fractures, and the ordinary rule of surgery should under no circumstances be deviated from. An expectant attitude, although it appears immediately satisfactory, exposes the patient to future risks which are incalculable, but none the less serious.'

Anthony Bowlby[3] states also that 'the necessity for operative treatment in tangential and perforating wounds will not be disputed by any surgeon, but when linear and slight gutter fractures are reviewed opinions may differ'; and, continuing, 'We would say without hesitation that all depressions, however slight and trivial looking, should be thoroughly

[1] *Lancet*, March 3, 1906.
[2] *Surgical Experiences in South Africa*, p. 293.
[3] *A Civilian War Hospital*, p. 228.

explored, as it is quite impossible for any one to say what the underlying damage is. As regards simple linear fractures, a definite rule cannot be laid down, and the question of operation must be settled by the condition of the patient and by the presence or absence of irritative, paralytic, or compression symptoms. Our own experience shows that it is better to operate when in doubt than to adopt an expectant attitude.'

From the above, and many other similar opinions, it may be accepted that practically all bullet-wounds of the skull and brain, whether inflicted by bullets of high or low velocity, call for early operative interference, it being granted that the condition of the patient is compatible with such treatment.

Operation. The operative details may be considered under two headings:—

(*a*) The exploration of the wounds of entry and exit.

(*b*) The search for and removal of the bullet.

The exploration of the wounds of entry and exit. Whether the skull be penetrated or perforated, the wounds of entry and exit are investigated after similar general principles. After careful shaving and cleansing of the skull and after application of the scalp-tourniquet, a scalp-flap is turned down, the centre corresponding, as far as possible, to the site of entrance or emergence of the bullet. The under aspect of the scalp-flap is first examined for loose portions of bone, hair, portions of headgear, &c. These are removed. The bone is next examined. All loose osseous fragments are removed, both small and large. The smaller are discarded; the larger are boiled (for ten minutes) and preserved in saline solution for replacement at the termination of the operation, if such a course should be considered advisable (see p. 216). Those fragments of bone which retain their pericranial attachments are merely elevated and turned aside, to be again placed in position at the proper time.

Trephining is seldom necessary, the size of the hole in the bone usually allowing of the ready application of the craniectomy forceps, if any enlargement of the gap should be desirable.

Loose fragments of bone being removed, depressed fragments elevated, and the requisite enlargement of the gap carried out, a good view of the dura mater is obtained. If the membrane be merely punctured or incised, the tear must be enlarged with blunt-pointed scissors so as to allow of complete examination of the underlying brain. Hæmorrhage from meningeal vessels is controlled by the application of ligatures to all vessels that cross the line of dural section.

The lacerated brain is gently irrigated with saline solution (at a temperature between 110° and 115° F.) and all blood and pulped brain matter washed away. The cortex is next examined with the finger

and probe for any fragments of bone that may be embedded in the brain substance. These fragments are seized with sequestrum forceps and carefully removed. The removal must be carried out with all possible precautions, and the search must be prolonged till the surgeon is fully satisfied that no foreign body remains. The bullet, when seen or felt, is removed.

If the brain be penetrated or lacerated, a drainage tube should be introduced through the scalp-flap (preferably through the wound of entry or exit) and through the dura mater, in such a manner that the distal end lies in relation to the bullet-track through the brain or flush with the lacerated area. The dura mater is elsewhere sewn up, and the scalp-flap sutured in position.

The tube should be allowed to remain for twenty-four to thirty-six hours, after which it can be shortened daily. Premature withdrawal of the drainage tube may lead to disastrous results.

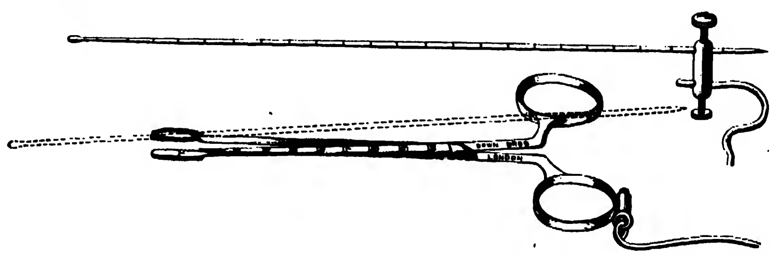


FIG. 133. SHEEN'S BULLET-PROBE AND FORCEPS.

The ultimate success of the operation depends to a great extent on the primary or early union of the wound.

The search for and removal of the bullet. In the event of there being only a wound of entry, it can generally be presumed that the bullet is within the skull. Bullets, however, pursue such unexpected and unusual courses through the brain that no attempt should be made at removal unless it is visible or palpable, except after complete X-ray investigation and localization, stereoscopic if possible.

As an exception to this rule, it may be stated that it is perfectly justifiable to carry out further exploration for the bullet when there is present, at the opposite side of the skull, what may be termed an 'attempted wound of exit', that is to say, an area of bone elevation and blood extravasation, suggesting that the bullet has impinged against the bone and produced an elevated fracture. Such conditions afford every justification for further exploration in the anticipation of finding the bullet. If such measures are indicated, a flap is turned down and the bone, dura, and brain explored in the manner previously indicated.

It cannot, however, be too forcibly urged that hasty and ill-determined explorations usually terminate in failure, for, even under the most promising conditions, it by no means follows that the bullet will be found near the site of counter-trephining, as it may rebound to some more distant region of the brain, thus necessitating trephining and exploration over a totally different region.

However, in certain cases of necessity where immediate operation is advisable, and in certain cases of expediency where no X-ray pictures are available, an immediate search for the bullet may be called for. The operation must be carried out with a light hand, and the search for the bullet should not be unduly prolonged. If the bullet be not found, it should be allowed to remain till such time shall have elapsed as will enable the surgeon to determine whether further procedures are required or not. It is well known that bullets in certain portions of the brain exercise but little effect on the individual, *e.g.* in the frontal lobe. Further measures depend largely on the cleanliness of the wound and on the situation of the bullet. All remote operations are planned according to the localizing symptoms present, aided by stereoscopic X-ray pictures.

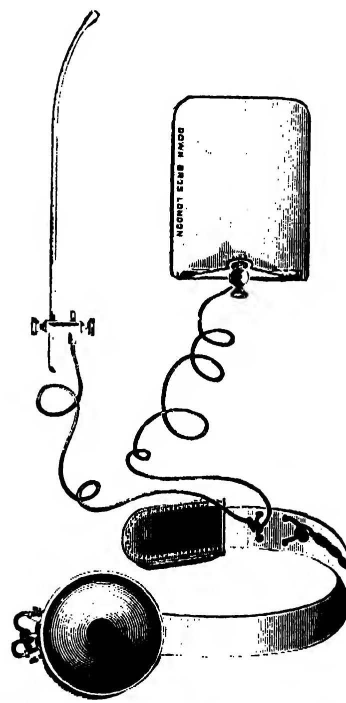


FIG. 134. SHEEN'S TELEPHONE BULLET-DETECTOR.

In order to find and remove the bullet, the bullet-forceps, probe, and telephone-detector suggested by Sheen[1] will be found of the greatest value. 'The forceps are so constructed that they may be attached directly to the telephone-detector and used as a combined probe and forceps, or they may be used in combination with the specially designed graduated probe attached to the detector in the following manner: The bullet having been located with the probe, the forceps are introduced along the probe, the jaws of the forceps being provided with an oblique groove for this purpose. In both methods of use the telephone-detector is in uninterrupted contact with the bullet during extraction, an advantage which much facilitates the operation, and ensures the least possible damage of tissue. In cases where the forceps are used as a probe and forceps combined, the connexion attached to the forceps is composed of silver

[1] *Army Med. Corps Journal*, April, 1905.

wire, which can be readily sterilized, and while of sufficient rigidity to avoid the risk of accidental short-circuiting with the patient's body, is flexible enough not to interfere with the delicacy of manipulation.

'The telephone-detector is placed on the head of the operator, and the flat plate on the patient's body, good contact being secured by means of a damp pad of lint, or other material, moistened with a saturated saline solution.

'The probe is introduced, and when a metallic foreign body is touched a fall of potential occurs, and the telephone buzzes. It is necessary to point out that no mistake can be made, as may be the case with a battery in circuit. In using the 'auto-telephone probe' the body constitutes an electrolyte, the plate one pole of a voltaic circle, and the probe the other; on touching a metallic body different to that of the probe, a difference of potential occurs, and the current ensuing flows through the telephone and is recorded by the diaphragm in the usual way.'

Sir Frederick Treves states that the instrument was of the greatest service in the South African War, especially where, as a result of the exigencies of warfare, it was impossible to obtain the services of a skilled radiographer.

After exploration and removal of the bullet an extensive osseous defect may remain. Opinions differ with regard to the time when an attempt should be made to remedy the deficiency. Bowlby[1] considers that the use of a thin platinum plate would possibly ameliorate some of the later complications by preventing the blending together of scalp, dura mater, and brain. The septic nature of the wound must, however, be taken into consideration, for the application of any plate of foreign material is, under such circumstances, almost inevitably doomed to end in failure. It is advisable, therefore, to postpone such measures till after the primary or early healing of the wound. Further delay, however, tends to allow of the formation of such adhesions as will result in the development of Jacksonian epilepsy, traumatic insanity, &c. The requisite operative procedures are dealt with in Chapter VI.

'The after-treatment consists in keeping the patient as quiet as possible, and the administration of fluid diet. In some cases recurring symptoms pointed to the continued presence of bone fragments: these were usually indicated by signs of irritation, or often by local inflammation, in the latter case infection taking the greatest share in the causation. Such cases needed secondary exploration, and the wonderful success of this operation, even when the wound was evidently infected, was perhaps one of the most striking experiences of surgery in general.'[2]

[1] *A Civilian War Hospital.*
[2] Makins, *Surgical Experiences in South Africa.*

Results. The prognosis in any given case depends on the degree of bone and brain injury, on the presence or absence of the bullet in the brain, and on the 'cleanliness' of the wound. In the American Civil War 61·2 % of all fractures of the skull terminated fatally, in the Franco-Prussian War 51·3 %, and in the South African War 33·1 %. The decreased mortality in the last case was undoubtedly the result of improved methods of treatment.

When the injury is inflicted at short range, the prognosis is undoubtedly less favourable. 'At short ranges, the characters of the wounds, and the severity of the symptoms, rendered the immediate prognosis uniformly bad, a very great majority of the patients dying, and that at the end of a few hours or days' (Makins).

The best results were obtained when the injury was received in the frontal region. The occipital region comes second. However, the most surprising recoveries were recorded, both with and without operative interference.

The prognosis with regard to pistol-shots is absolutely bad. Phelps [1] records the following results in cases that came under his own observation :—

Death occurred at once or within the first hour in 15 cases.
Death occurred within twelve hours in 7 cases.
Death occurred within fifteen hours to forty days in 10 cases.
Recovery in but 8 cases.

The more remote results are exceedingly difficult to determine, for it is quite impossible to obtain an accurate record of the subsequent history of those cases that recovered. With regard to the question of the after-history Makins writes, 'I feel certain that a long roll of secondary troubles from the contraction of cicatricial tissue, irritation from distant remaining bone fragments, as well as mental troubles from actual brain destruction, await record in the near future.' In the experience of the writer, this statement is fully justified. The hospital surgeon continually meets with cases exemplifying the more remote effects, varying from slight lesions associated merely with chronic headache to others showing considerable deficiency in the vault of the skull with marked cortical degeneration.

Some of these cases are still capable of being cured, others are hopelessly inoperable.

In the consideration of the more remote results, it must be remembered that the surgeon only meets with those cases that require advice or operative treatment. The more favourable cases are usually lost to view. Hence the difficulty in estimating with certainty the absolute results obtained after lesions of this nature.

[1] *Traumatic Injuries of the Brain*, p. 387.

CHAPTER VI

OPERATIONS FOR TRAUMATIC EPILEPSY AND INSANITY: CLOSURE OF DEFECTS IN THE SKULL

OPERATIONS FOR TRAUMATIC EPILEPSY, TRAUMATIC INSANITY, AND GENERAL PARALYSIS OF THE INSANE

A GREAT difference of opinion exists with regard to the amenability of cases of traumatic epilepsy, insanity, &c., to surgical treatment. Some surgeons urge operative treatment and report enthusiastically on their results, others express their opinions in the gloomiest possible terms. These divergent views are readily explained when it is considered that no absolute rules can be laid down as to the suitability of a case for operation, for the simple reason that no one can foretell with certainty the pathological conditions present. The symptoms may be due to the mere adherence of the scalp to the bone, to osteosclerosis, to depression of bone, matting of membranes, subdural hæmatocele or cyst, and to scarring of the brain. Some of these conditions are capable of cure, others of alleviation. The enthusiasts may have been exceptionally careful in their selection of cases or unusually lucky in the pathological conditions found at the time of operation. However, in general it may be concluded that the surgeon, though very guarded in his prognosis, should generally be biased in favour of operative treatment, and should urge the same when both local and general conditions are favourable.

Indications. A. **In traumatic epilepsy.** According to the late Professor von Bergmann,[1] the indications for operation are as follows :—

(i) Recent cases with infrequent attacks of epilepsy.

(ii) Cases which have manifestations on the skull or scalp of previous injury.

(iii) Cases which have symptoms described as Jacksonian in character.

The suitability of a case for operative treatment hinges to a great extent on the presence or absence of cortical scarring and tract degeneration. If such changes are present, there can be but little expectation of ameliorating the patient's condition. In favourable cases, and especially in those that fulfil the indications laid down by von Bergmann, con-

[1] *System of Surgery*, vol. i.

siderable improvement may be attained by adopting operative measures, with now and again a complete cure.

In order to avoid disappointment, it should be explained to the patient, or patient's friends, that one of the three following results may be anticipated :—

1. A complete cure, for which it is necessary that favourable local conditions should be found, and that the patient should be so circumstanced as to be enabled to take complete rest, physical and mental, for one year after the date of the operation.

2. An alleviation of symptoms, the fits becoming less frequent and less severe, and the general mental and physical condition much improved.

3. A temporary improvement only, the symptoms recurring at a later date, but the fits, &c., not more severe than before.

B. **In traumatic insanity, &c.** Powell[1] pointed out that, in the very great majority of cases of traumatic insanity, the injury is comparatively superficial, resulting in depression of the bone, pachymeningitis, osteosclerosis, &c., and that only in a very few cases is the deeper cerebral tissue diseased. In 67 cases, 27 showed depressed bone, 15 osteophytes or splinters, 4 cysts, and 7 pachymeningitis.

Duret[2] draws attention to three main points: the great nervous sensibility of the dura mater, the absence of cerebral changes, and the almost instantaneous cure of some cases after trephining and removal of the irritating cause. He argues that the nervous phenomena in traumatic insanity are, in most cases, reflexly due to meningeal irritation.

All available evidence tends to show that the opinions of Powell and Duret, with regard to the presence of an exciting cause, are correct, such conditions being found in a large proportion of cases. Operative treatment is indicated, therefore, in all cases where the history of the case or the local conditions suggest the possibility of some local pathological lesion.

Operative measures to be successful must be carried out at an early stage of the trouble, before cortical degenerative changes have had time to occur.

C. **In general paralysis of the insane.** Claye Shaw[3] writes: 'I am quite sure that a surgical operation should only be resorted to when other remedies have failed, but if it be granted that pressure exists in acute insanity, either of the excited or depressed type, and ordinary measures seem useless, it would appear that nothing is left but the operation.' Some Continental surgeons are more insistent on the urgency of adopting

[1] *Traumatic Insanity*, Oxford, 1893.
[2] *Sur les traumatismes cérébrales.*
[3] *The Journal of Medical Science*, October, 1894.

operative measures in the earlier stages of this disease. In the experience of the writer, the early results of operation are fairly favourable, but no permanent benefit has been obtained.

In the operative treatment of traumatic epilepsy and insanity, the surgeon has evidence of external injury, the lession varying from a scalp-scar adherent to the bone to an extensive osseous deficiency. The operations suited to these conditions are described below. In the surgical treatment of general paralysis 'decompression' operations are indicated, for which reference should be made to p. 219.

Operation. Though the operative details vary according to the circumstances of the case, the preliminary details are identical. The scalp is shaved and cleansed in the usual manner, the head enveloped in gauze, and the scalp-tourniquet applied (see p. 195).

The formation of the scalp-flap. *When the scalp is adherent to the bone*, the incision, carried throughout down to the bone, is made in such a manner that the scalp-flap, when turned down to its base, will permit not only of the detachment of the scar but also of the complete exposure of the neighbouring portion of the skull. In the region where the scalp was adherent to the bone all fibrous tissue and thickened pericranium are carefully dissected away to allow of adequate inspection of the bone itself.

When the scalp is adherent to dura or brain, as the result of the osseous deficiency, the edge of the knife should be directed towards the under aspect of the flap, and the flap carefully peeled away from the region of the gap and from adherent membranes, &c.

The examination of the bone. Careful search is made for a fissured or depressed fracture or other evidence of osseous lesion.

When no fracture is found, the question arises as to whether further measures are indicated or not. Although it cannot be denied that fits, &c., may arise merely as a result of the adherence of the scalp and bone, yet it is clearly established that such cases are exceedingly rare. As a general rule, therefore, the operator should trephine over the cortical area from which the trouble appears to emanate in order to exclude the possibility of the existence of depression of internal table, subdural hæmatoma, arachnoid cyst, &c.

When a fissured fracture is found, the bone should be trephined where the line of fracture crosses that region of the brain from which the symptoms appear to originate.

When a depressed fracture is found, the trephine is applied in such a manner that the trephine circle just includes the outer segment of the depression. During the trephining, special care must be taken to avoid damage to the dura mater which is probably adherent to the under

aspect of the bone. After removal of the disk, the dura is stripped away from the bone and the depression rectified with the elevator and craniectomy forceps (see Fig. 125). In the event of failure to lever the depression outwards it will be necessary to cut away the whole of the depressed bone. De Vilbiss's forceps enable the operator to cut a narrow channel around the affected region, after which the isolated piece of bone can be readily removed. In any case, it is absolutely essential that a good view be obtained of the underlying dura.

When there is osseous deficiency, it will be found that the gap in the bone is filled up with dense fibrous tissue, adherent to the margins of the bone and possibly to both dura and brain as well. It is absolutely essential that this tissue should be removed, for all available evidence points to the fact that meningeal irritation is the main cause of the fits, &c.

The removal of the fibrous tissue is best carried out by beginning at the most promising part of the gap, detaching the tissue adherent to some more prominent portion of bone, and exposing the underlying dura mater. The dura is then separated from the bone in a direction away from the centre of the gap, and the craniectomy forceps applied till sufficient room has been obtained to allow of the introduction of some blunt instrument and the insinuation thereof between the scar tissue and the dura mater. It now remains to remove the central mass of fibrous tissue, a simple procedure when it is not adherent to the dura or brain, and carried out as follows: The dura mater and scar tissue are separated from one another, the scar tissue seized with pressure-forceps, lifted up, detached from the margins of the gap and removed. In the more complicated cases, where the scar tissue is adherent to the dura mater and brain, careful dissection is required. In most cases it is necessary to remove that part of the dura mater which is included in the scar. The cerebral substance should be carefully protected (see below).

The treatment of the dura mater. When the dura has not been injured during the process of exposure, pulsating freely and presenting a normal appearance, preparations can be made to close in or protect the deficiency in the vault.

When the dura bulges outwards, and when, in other respects, the indications point to an increase of intradural pressure, the membrane is incised crucially and further investigation carried out in the search for a subdural hæmatoma, arachnoid cyst, or other lesion. A hæmatoma is washed out and drained; an arachnoid cyst is either shelled out entire or treated by excision of the parietal wall, with subsequent drainage.

When the dura is thickened, matted, and adherent to the brain, it should be picked up at the least adherent part and carefully dissected away, exposing the loose mesh-work of the pia-arachnoid region. The

surface of the brain being so brought into view, the use of the scalpel and dissecting forceps may be further required to remove all tags and shreds of matted tissues, this process being continued till a reasonably healthy region has been brought into view.

The treatment of a cortical scar. There is no reason why the more superficial portion of a cortical scar should not be freely removed, but, unfortunately, such removal is almost necessarily followed by the formation of another scar, at least as extensive as the original fibroid condition. The removal of cortical scars has, therefore, justifiably fallen into disrepute, and most surgeons content themselves with an exposure of the pia-arachnoid region, the actual cerebral substance being left untouched. All hæmorrhage must be arrested, bleeding points being clamped or underrun and tied with fine catgut. The occurrence of hæmorrhage after the reposition of the scalp favours the formation of fresh adhesions.

The prevention of fresh adhesions between the dura and the brain, and between the dura and the scalp. Many measures have been advocated. It has been recommended that some foreign substance should be inserted, such as fresh egg-albumen, gutta-percha, silver and gold foil, between the brain and the dura, the latter membrane being gently lifted up and the medium insinuated beneath. Experience shows, however, that all these substances are comparatively useless, being either invaded or surrounded by granulation-tissue and, later on, absorbed or enclosed in dense fibrous tissue. English[1] says, 'It is useless to talk about the prevention of adhesions; they will form in spite of anything that may be done.' In suitable cases, however, the adhesion of the dura to the brain may be prevented by stitching that membrane to the pericranium.

The prevention of adhesions between the dura and brain on the one hand and the scalp on the other, and the closure or protection of gaps in the skull, are subjects so intimately allied that they are necessarily considered together.

THE CLOSURE OR PROTECTION OF DEFECTS IN THE SKULL

Indications. Operative measures for the closure or protection of gaps in the skull are indicated in the following conditions:—

(i) Large defects, post-operative or traumatic.

(ii) Small defects situated over exposed portions of the skull or over the more important regions of the brain.

(iii) Both large and small defects associated with chronic fixed headache, insanity, Jacksonian epilepsy, &c.

(iv) Certain congenital deficiencies in the vault.

[1] *Lancet*, Feb. 27, 1904, p. 563.

Small defects, unless situated in exposed regions or associated with symptoms, require no active treatment. The gap becomes diminished in size by the inward growth of the surrounding bone and by the development of fibrous tissue of such density that the underlying structures are effectually protected.

Methods. The methods that have been adopted for the closure or protection of gaps in the skull may be classified as follows :—

(1) The formation of bone-flaps—

Derived from the neighbouring portion of the skull.

Derived from some other bone of the patient.

Derived from the bones of a freshly-killed animal.

(2) The interposition of plates of some foreign material between the scalp and the bone, or the insertion thereof into the osseous deficiency.

Bone-flaps. *The osteoplastic method of König and Müller.*[1] Two flaps are formed in the manner described below and the two interchanged in position. A Ω-shaped flap, comprising the whole thickness of the scalp, is turned down so as to expose the region of the deficiency. The incision is carried down to the bone throughout, and should lie about ½ inch away from the margins of the gap. The flap is carefully dissected from underlying structures to which it may be adherent, and every precaution taken to avoid damage to those arteries that enter along the base of the flap and which minister to its vitality. All bleeding points are clamped and tied.

A second flap is framed from the scalp immediately to one side of the first flap. This second flap corresponds in size and shape to the one already made, but differs in having its base pointing in the opposite direction. It is also peculiar in that it consists of the whole thickness of the scalp, together with the external table of the skull. The scalpel is carried down to the bone, and the margins of the incision retracted in such a manner as to allow of the application of the hammer and chisel. The external table is cut through along the line of the scalp incision, and split away from the rest of the bone. The two flaps are then interchanged in position and sewn down with salmon-gut sutures.

The osteoplastic flap is by no means easy to frame, the external table tending to break up during the process of separation; moreover, its formation is confined to those parts of the skull in which the two tables are separated by diploic tissue. The operation is, therefore, limited to the occipital, parietal, and frontal regions. The frontal region should, however, be generally excluded from participation in this mode of treatment on account of the deformity and scarring that necessarily ensue.

[1] *Centralbl. für Chirurgie*, 1890, pp. 65 and 497.

Many cases also have been recorded in which the raw surface of the bone-flap has contracted fresh adhesions to the underlying parts, thus defeating one of the main objects that the surgeon has in view.

In suitable cases, however, a good result may be anticipated. Asepsis is absolutely essential.

Bone-flaps derived from the bones of the patient, or from those of a freshly-killed animal. A bone-graft may be cut from the tibia of the patient or from any suitable bone of a freshly-killed animal. The gap in the skull is first exposed, the margins refreshed, and the size and shape estimated. The bone-graft is then cut from the other bone, suited in every respect to the deficiency that is to be filled in, inserted into the gap, and sewn into position. The ultimate results obtained by this method are by no means satisfactory. They may be classified as follows :—

(*a*) The bone-graft may retain its vitality and completely close in the gap.

(*b*) The graft may act as a foreign body, become invaded by granulation-tissue and be more or less completely absorbed.

(*c*) In the event of the slightest failure in aseptic technique, suppuration occurs, and continues till the wound has been reopened and the graft removed.

The attendant difficulties and frequent failures in these auto- and hetero-transplantations of normal bone led to the utilization of decalcified, calcined, and boiled bone-plates. Between these media there is but little to choose, for it is generally accepted that bone-grafts, of whatever nature, usually act merely as a scaffolding medium for the formation of fibrous tissue. The absorption of decalcified bone-grafts results, according to Barth, from the absence of the calcium salts which are so essential to the life of the graft and the formation of new bone. Calcined and boiled grafts presumably owe their ultimate absorption to the fact that the bone-cells are destroyed in the process of graft preparation.

Opinions are correspondingly divergent as to the most suitable method of protecting or closing in the gap in the skull. Senn recommends calcined bone, Mertens and Westermann boiled bone, whilst Leedham-Green [1] advises the König-Müller flap in the first case, and, in the event of failure, boiled bone-grafts.

Plates of some foreign material. Gold plates are expensive, and present no material advantage over the cheaper metal, silver. Aluminium is strong and light, but insufficiently malleable. Celluloid is strongly recommended by Fraenkel, Pringle,[2] and others. Pringle uses plates

[1] 'On the Closure of Traumatic Defects in the Skull,' *Brit. Med. Journ.*, 1905, p. 819.

[2] 'On Closure of Gaps in the Skull,' *Brit. Med. Journ.*, 1906, p. 246.

about $\frac{1}{16}$ inch thick, moulded slightly by immersion in hot water, and then inserted within the margins of the gap. He reports favourably on the results obtained.

In those cases, however, in which the writer has deemed it necessary to close in or protect gaps in the skull, the following method has been found to give satisfactory results:—

The plates utilized are of pure annealed silver, $\frac{9}{1000}$ inch in thickness (No. 2 Birmingham, Metal Gauge). The plates are light and of fair malleability. Supposing now that it is required to protect a deficiency in the vault—irregular in shape, round or oval, it matters not—the maximum antero-posterior and vertical diameters are measured before operation, and a piece of silver is cut out which is about $\frac{1}{2}$ inch longer in both diameters. The convexity of the skull in the region of the gap is roughly estimated and the plate hammered into corresponding shape. This process is readily carried out by laying the plate on a heavy leaden base and hammering to the required curvature. The convexity is regulated by the site of application of the blows, the heavier being applied to the central or apical portion of the plate, the weaker to the periphery. A rough general convexity is so produced. The edges of the plate are smoothed with the file, and three or four holes bored through it to allow of the escape of any blood or cerebro-spinal fluid that may collect beneath it after application.

The plate is boiled and then applied as follows: The osseous defect is fully exposed by the formation of a scalp-flap (not including the pericranium) framed by means of an incision which lies fully 1 inch distant from the margins of the osseous deficiency. The flap is turned down to a base which is situated not more than $\frac{1}{2}$ inch below the lower border of the gap. The pericranium is stripped away towards the periphery. The plate is then applied so that it rests below against the base of the scalp-flap, lies throughout between the scalp and bone, and overlaps the margins of the gap by about $\frac{1}{2}$ inch. The pericranium is heaped up around and over the margins of the plate, and the scalp-flap replaced. The plate is maintained in position by the support received below from the base of the flap, marginally by the pericranium, and generally by the reposition of the scalp-flap. In the process of time, new bone is formed by the pericranium, this and the fibrous tissue developed along the line of the scalp incision fixing the plate accurately and firmly in position.

In the majority of cases in which this method has been carried out the patients have not complained of any inconvenience, either from the weight of the plate or from other cause. Needless to say, absolute sterility of the field of operation and of all media is essential. In the

event of suppuration, however slight, it will become necessary to reopen the wound and remove the plate.

Results. **Of operations for traumatic epilepsy.** The immediate results of operation are undoubtedly very satisfactory, but the more remote results are by no means so encouraging. For some weeks or months after the operation there is nearly always a decided improvement in the condition of the patient, but a subsequent relapse is frequently noticed. Of 12 cases that have come under the care of the writer a complete cure was obtained in 2, both these patients having been kept under observation for a considerable period of time. In 5 cases a definite improvement in the conditions was obtained, whilst in 5 others there was no material change.

The early benefit that results, and the subsequent relapse that so frequently obtains, suggest strongly that the recurrence of the trouble arises from the re-formation of adhesions. It is our technique that is at fault in the main. There is, however, every reason to believe that fairly satisfactory results may be obtained if suitable cases only are submitted to operation. Statements with regard to prognosis must always be of the most guarded nature.

Of operations for traumatic insanity. In the 67 cases reported by Powell,[1] death occurred in 5. In the 62 recoveries, the following results were obtained :—

41 cases of mental recovery.
12 cases of mental improvement (great).
5 cases of mental improvement (slight).
4 cases in which there was no change.

[1] *The Treatment of Traumatic Insanity.* Oxford, 1893.

CHAPTER VII

OPERATIONS FOR INTRACRANIAL SUPPURATION

Indications. With regard to the desirability of operative treatment for pus pent up within the skull, no special indications are required. Free drainage must be supplied at the earliest possible moment, granting, of course, that the general condition of the patient is compatible with operative interference, and that the site of infection can be diagnosed with a reasonable degree of accuracy. It must, however, be pointed out that even when the patient is almost moribund from the presence of a cerebral or cerebellar abscess, the evacuation of the pus not infrequently leads to the happiest results. Furthermore, when the localizing features are but ill defined, much may be done to diminish the general increase in the intracranial pressure, thus allowing of time in which to perfect the diagnosis and adopt further measures.

In other words, experience shows that but few cases can be regarded as absolutely hopeless, however desperate they may appear to be.

The majority of cases of intracranial suppuration that come under the care of the surgeon are either secondary to chronic middle-ear disease, or prolonged suppuration in the accessory sinuses of the nose. These are dealt with in Vol. IV.

Only two varieties of cases of intracranial suppuration will be considered in this section, those which are traumatic in origin and those which, though apparently secondary to aural or nasal disease, are best treated by trephining and exploration of the brain. For instance, the surgeon often prefers to explore directly for a temporo-sphenoidal abscess, postponing the mastoid operation to a future date. Such a course presents certain obvious disadvantages, but it is one that is called for under certain circumstances. Firstly, when the general condition of the patient prohibits the prolonged procedures essential to the mastoid and similar operations; and secondly, when the operator, from inadequate knowledge of the minute anatomy of the middle ear, prefers to avoid a search for the abscess cavity along the 'stalk of the abscess'.[1]

[1] Ballance (*Some Points in the Surgery of the Brain*, p. 95) first pointed out that most brain abscesses secondary to disease of the bones of the skull are mushroom-shaped, the narrow portion or stem being attached to the dura at the original site

Two further points require consideration with regard to the relative advantages of trephining without primary mastoid operation.

Firstly, with regard to the adequacy of the drainage supplied. Macewen [1] points to the desirability of exploring and draining a temporo-sphenoidal abscess through the squamous bone, and lays stress on the incomplete nature of the drainage supplied after exploration through the tegmen tympani. Again, when the evacuation of a cerebellar abscess is under consideration, it would appear that more efficient drainage can be established when the operation is carried out through the lower cerebellar region than through the eroded posterior wall of the middle ear.

Secondly, it should be noted that an unsuccessful attempt to find the abscess after exploration through the tegmen tympani, or other part of the petrous bone, carries with it an appreciable risk of meningeal and brain infection, insomuch as the exploration is conducted from the infected middle ear. Exploration through the 'clean' squamous and cerebellar regions presents no such disadvantages.

Each case must be treated on its own merits, the surgeon being naturally disposed to adopt those measures with which he is most familiar.

The following conditions require consideration:—

1. Extra-dural suppuration.
2. Meningitis.
3. Abscess of the brain.
4. Hernia cerebri.

OPERATION FOR TRAUMATIC EXTRA-DURAL SUPPURATION

Operation. After the application of the scalp-tourniquet, a scalp-flap is framed and turned down, the incision being so planned as to fully expose the diseased area of bone. The subsequent measures vary according to the conditions present.

Where no fracture is found, but where the appearance of the bone and pericranium suggests the possibility of an extra-dural focus of pus, the pin of the trephine is placed over the centre of the unhealthy bone, the disk of bone removed, and the pus allowed to escape. With the aid of the dural separator the extent of the collection is estimated, and the opening in the skull enlarged with the craniectomy forceps in the required direction. It is essential that adequate drainage should be supplied. The pus should be wiped away with the sponge and gauze, and no irrigation

of infection. The stalked form of abscess is 'quite comparable, as to its mode of formation, to a superficial cervical abscess connected by a narrow track to a focus of disease beneath the deep fascia'.

[1] *Pyogenic Diseases of the Brain and Spinal Cord*, p. 313.

used. It has been recommended that the dura mater should then be lightly scraped with Volkmann's spoon. Such measures are, however, to be condemned, insomuch as the sodden dura may be injured and the patient thereby exposed to the risk of a general meningeal infection. After thorough exposure and cleansing, the abscess cavity is plugged lightly with narrow strips of gauze, the ends of which are brought out at the most convenient and dependent part of the scalp-flap.

In the event of the surrounding bone presenting an unhealthy appearance, the external table and diploic tissue must be freely removed. The external table can be cut away with the hammer and chisel, with the trephine, or with rose-headed burrs and drills. If the condition of the patient allows of the requisite prolongation of the operation, the trephine should be used, the external table of the skull being cut away till a region is attained where the bone appears normal. The diploic tissue is scraped away with Volkmann's spoon, and the exposed internal table sponged with undiluted carbolic acid, every precaution being taken to protect the dura mater from contact with the acid. The whole region is then sponged over with a weak antiseptic solution and lightly packed with gauze.

If a fissured fracture be found, the pin of the trephine is applied where the line of fracture crosses the central part of the unhealthy bone.

If the skull be depressed or comminuted, the fragments are elevated or removed, with or without trephining, and the abscess treated as described above.

OPERATIONS FOR MENINGITIS

Anatomical considerations and pathological experience evidence the futility of operative measures when the infection is widespread. It has been proposed that, even under such adverse circumstances, a counter-opening should be made, either opposite to the site of primary injury or in the cerebellar region, irrigation being then carried out between the two holes. Such measures are, however, unwarrantable and impracticable—unwarrantable because the irrigation must inevitably infect the whole of the subdural space intervening between the two holes, impracticable because the outward bulging of the brain in the region of the trephine holes effectually prohibits all such measures.

The surgeon has, therefore, in the operative treatment of meningitis, two main objects in view:

(*a*) To lessen the risk of a general infection by early exploration in all doubtful cases.

(*b*) To establish adequate drainage.

These two objects being fulfilled, some further aid may be obtained by lumbar puncture and by serum-therapeutic treatment.

With regard to the necessary operative measures, reference should be made to the section dealing with the operative treatment of fractures of the skull.

OPERATIONS FOR ABSCESS OF THE BRAIN

Acute traumatic abscess. An acute abscess arising from direct infection from a compound fracture of the vault usually develops within two weeks of the accident, being, in fact, more after the nature of a meningo-cortical abscess than a brain abscess proper. Now and again, cases are reported in which the purulent collection was late in development, firmly encapsuled, and situated deep in the white substance of the brain. Such cases are very rare.

The measures that can be adopted for the evacuation of a meningo-cortical abscess vary according to the condition of the overlying bone.

Where no fracture is found, the bone is trephined over the region from which the trouble appears to emanate, and the dura investigated. If that membrane be already lacerated by depressed fragments of internal table, an enlargement of the rent with blunt-pointed scissors will suffice to fully expose the abscess. Under other circumstances, the bulging membrane is freely incised and the abscess laid bare. Should it be found that free drainage cannot be supplied through the trephine hole, the bone must be cut away in the required direction and the dural incision prolonged accordingly. The pus is sponged away and the cavity lightly packed with gauze. Irrigation is contra-indicated on account of the attendant risk of meningeal infection.

Where a fissured fracture is found, the skull is trephined where the fracture crosses the region from which the trouble appears to arise.

Where a comminuted fracture is found, the fragments of bone are elevated and removed until sufficient exposure of the dura mater has been obtained.

Temporo-sphenoidal abscess. After the usual preparatory treatment, a point is chosen on the surface of the scalp which lies between 1½ and 2 inches above the centre of the external auditory meatus. This point may be recognized on the bone by introducing a bradawl through the scalp in such a manner as to indent the external table. A suitable scalp-flap is turned down and the trephine applied. The trephine should present a diameter of not less than 1 inch. In the squamous region of the skull the two tables are in practical apposition, and every precaution must therefore be taken to avoid damage both to the posterior branch of the middle meningeal artery, which ramifies in the immediate neighbourhood, and to the bulging dura mater. After

the removal of the disk of bone, the dura is inspected; absence of pulsation, marked outward bulging, and loss of lustre indicate the probable adjacency of the abscess cavity. The membrane is crucially incised, any meningeal vessels that cross the proposed line of dural section being first ligatured or underrun on either side of that line. The scalpel is applied lightly to the dura, and, as soon as the pia-arachnoid is exposed, the section completed with the blunt-pointed scissors. By adopting these precautions there is but little chance of causing troublesome complication by damaging superficial cerebral veins.

The four dural flaps are turned aside and the cortex exposed. At the very apex of the bulging brain, and avoiding all visible vessels, a large trochar and canula or Horsley's pus evacuator (see Fig. 135) is introduced and passed for not more than 1½ inches, in a direction slightly forwards and inwards, parallel to the tegmen tympani. The blades of the evacuator must be opened 'once for each quarter of an inch of brain substance penetrated' (Macewen). If the trochar and canula be used, similar precautions must be taken. In the event of failure to find the abscess at the first attempt, the evacuator is withdrawn, introduced at the same site as before, but passed in other directions, directly inwards, forwards, and backwards, in each case for not more than 1½ inches.

Fig. 135. Horsley's Pus Evacuator.

By wide separation of the blades of the evacuator the pus is allowed to escape, to be immediately sponged away by the assistant. Irrigation of the cavity should never be carried out, the process being exceedingly difficult to accomplish effectually, on account of the narrowness of the track which leads from the abscess cavity to the surface of the brain, whilst there is furthermore considerable risk of infecting the surrounding meningeal territory.

Before the withdrawal of the evacuator a drainage tube is inserted, projecting into the abscess cavity, and brought out through the scalp-flap. The tube may be shortened daily, to be withdrawn finally after four days or more, according to the progress of the case.

Before dealing with cerebellar abscess, it will be necessary to allude to certain points in the operative technique peculiar to the treatment of chronic abscesses (encapsuled). Abscesses of this nature may occur in any part of the brain, and the surgeon must be prepared to deal with the same.

Chronic encapsuled abscess. Both the trochar and canula and Horsley's pus evacuator have a great tendency to merely impinge against and push aside the dense wall of a chronic abscess without penetrating it. If, from the nature of the case, it be suspected that the abscess is of the chronic type, it should be explored for and treated after the following manner: After exposure of the brain, a small blunt probe is introduced in the direction of the abscess and the brain probed until the resistance of the abscess-wall is encountered. A grooved director is passed along the probe and the latter instrument withdrawn. By gentle side-to-side movements the passage through the brain is enlarged until a view can be obtained of the abscess-wall. A head-lamp will be found of great assistance. The margins of incision into the brain are held aside with small retractors, and the wall of the abscess incised with tenotomy knife or small scalpel. It is now possible to introduce a drainage tube. In the experience of the writer, however, it has been found that such procedures seldom lead to a satisfactory result, the tube being extruded and the abscess filling up again. For instance, a case of frontal abscess was twice incised and drained before it was realized that a cure could not be brought about in this manner. Wherever possible, therefore, the abscess should be completely removed. The margins of the incision through the wall of the abscess are seized with narrow-bladed clamps, gentle traction applied, and the surrounding brain substance carefully peeled away with the handle of the scalpel or periosteal elevator. As a rule, there is no great difficulty in carrying out this proceeding, and the hæmorrhage is seldom severe. After complete removal of the abscess-wall a drainage tube is introduced and the cavity lightly packed with gauze. The packing is allowed to remain for twenty-four to thirty-six hours, after which it is withdrawn and the space again lightly plugged. The repacking is continued till the cavity is practically obliterated. The closure often takes place with astonishing rapidity, and results from the falling together of the surrounding brain, from the formation of fibrous tissue, and the dragging in of the overlying scalp.

Cerebellar abscess. The abscess usually occupies the antero-external aspect of the lateral lobe of the cerebellum. It can be drained with advantage below the level of the lateral sinus and behind the posterior border of the mastoid process. A scalp-flap is framed as follows: The skin incision extends from the middle line, 1 inch below the external occipital protuberance, along the superior curved line of the occipital bone, to the upper and posterior part of the mastoid process, and then, in a downward direction, to the apex of that process. The incision is carried throughout down to the bone, and the cutaneo-muscular flap detached with the scalpel and periosteal elevator. The flap must be carried down as

rapidly as possible, for the hæmorrhage is severe. The bleeding not only occurs from divided occipital vessels but also from the mastoid emissary vein. Bleeding from the former source is controlled by clamps, that from the latter by introducing a small blunt probe into the foramen and working it round so as to destroy the lining membrane and so induce coagulation. More permanent occlusion can be brought about by blocking the foramen with a small piece of catgut, well rammed home.

The trephine is applied so that the circle falls immediately short of the lateral sinus above and the posterior border of the mastoid process in front. The trephine should be manipulated in the direction depicted in Fig. 137. It is necessary to remember that the wall of the cerebellar fossa is very thin. After the removal of the disk of bone, the gap may require to be enlarged with the craniectomy forceps. The dura is incised after the manner described in the operations for temporo-sphenoidal abscess, and the search for the abscess carried out with the same general precautions.

In this case, however, the evacuator is passed in the forward and inward direction towards the posterior border of the petrous bone. The abscess should be reached within 1½ inches from the opening in the skull. Before the removal of the evacuator a drainage tube is inserted, and the cavity drained as described previously.

Ballance[1] has recently pointed out that cerebellar abscesses are occasionally of a bifid nature, two cavities being superimposed and communicating with one another by means of a narrow channel. Any failure at symptomatic relief after drainage of a cerebellar abscess should suggest the possibility of the presence of such a condition.

Frontal abscess. Abscesses of the frontal lobe are most commonly secondary to disease of the frontal sinus. The abscess is, however, usually situated so far back in the frontal lobe and connected with the source of the trouble by so long a track or stalk of infection that considerable difficulty may be experienced in attempted drainage from the frontal or nasal regions; moreover, all operations carried out from the frontal region result in great deformity. The larger abscesses also give rise to such localizing symptoms, by reason of the backward pressure exercised on the corona radiata from the motor region, that the operator is frequently induced to approach the abscess cavity from the temporo-frontal region. In this situation the bone is thin, the operation can be conducted through the fibres of the temporal muscle, excellent drainage can be supplied, and no conspicuous scar results.

For a general description of the intermusculo-temporal operation the reader is referred to p. 220. In this case the operation is carried out

[1] *Some Points in the Surgery of the Brain.*

after the same general principles, with the exception that the field of operation is shifted further forwards. The skin incision starts at the external angular frontal process, curves along the temporal crest, and terminates in front of the ear. The temporal fascia and muscle are divided by an incision which is carried down to the bone and which passes in a direction obliquely downwards and backwards, so as to expose the front part of the temporo-frontal region. The bone is trephined and the search for the abscess carried out after the manner described in dealing with temporo-sphenoidal abscesses.

Difficulties and dangers. *Failure to find the abscess* is usually due to one of the following causes :—

(*a*) The abscess may be missed if the localizing features are misleading, if the abscess be small, and if the exploring instrument be passed in the wrong direction or to an insufficient depth.

(*b*) The abscess may be traversed but not tapped if unsuitable exploring instruments are used,—an aspirating syringe, for instance, through which the thick pus is unable to escape. Even when suitable instruments are used the attempt to evacuate the abscess may fail if the operator does not carry out what may be called a 'system of progressive exploration', that is to say, the periodical opening of the blades of the evacuator (see p. 253).

(*c*) The abscess may be encountered but not penetrated if the surgeon has to deal with a chronic abscess, the wall of which is merely pushed aside by the advancing instrument. Such an occurrence may be prevented by carrying out the procedures advocated in the section dealing with the operative treatment of such conditions (see p. 254).

Leakage into the neighbouring pia-arachnoid is a complication that is fortunately of infrequent occurrence, mainly owing to the fact that the general increase of intracranial pressure so causes the brain to bulge outwardly against the trephine hole that the subdural and subarachnoid spaces are practically cut off from the field of operation. Furthermore, in some cases, and especially when the abscess is situated near the surface of the brain, adhesions have formed between the membranes, cementing them together and affording an efficient barrier to meningeal infection.

Osteomyelitis of the diploic tissue can generally be prevented by providing efficient drainage, by protecting the exposed bone with strips of gauze, and by touching up the exposed diploic tissue with undiluted carbolic acid.

Perforation of the ventricular space may occur under two conditions: (1) when the abscess is associated with internal hydrocephalus, and (2) when the exploring instrument is introduced too far. The latter

complication can be prevented by carrying out the regulations laid down in the section dealing with temporo-sphenoidal abscess.

Hæmorrhage is seldom serious if the dura mater be incised in such a manner as to avoid injury to meningeal arteries, and if the evacuator be introduced so as to avoid the superficial cerebral veins. Hæmorrhage is most likely to result during the complete removal of a chronic abscess. In such cases every precaution must be taken to keep close to the wall of the abscess.

Respiratory failure is by no means an unusual feature in trephining, especially under two conditions: (1) when there is a marked increase in intracranial pressure, (2) when the operation is conducted in the cerebellar region. Respiratory failure should act merely as an incentive to the surgeon to complete the trephining as soon as possible and so relieve the compression of the brain. In the more serious cases, artificial respiration may be necessitated.

Results of operations upon brain abscess. It has only been recognized recently that an uncomplicated brain abscess—not associated with lateral sinus thrombosis and the like—offers by no means an unfavourable prognosis. Sir William Macewen,[1] to whom so much is due in the advancement of cerebral surgery, states that 'an uncomplicated cerebral abscess, whose position is clearly localized, if surgical measures are adopted for its relief at a sufficiently early period, is one of the most hopeful of all cerebral affections'. The same authority writes, 'After evacuation of the abscess, not only is the patient likely to recover, but in many cases it leaves no perceptible bodily or mental changes.'

The following statistical table, culled from Macewen's published reports, will demonstrate sufficiently the results that can be obtained by early operative treatment:—

	Cases.	*Operated on.*	*Cured.*	*Died.*
Extra-dural abscess	5	5	5	0
Leptomeningitis .	12	6	6	6 (all without operation)
Brain abscess—				
Meningo-cortical .	4	4	4	0
Temporo-sphenoidal	10	9	8	2 (one without operation)
Frontal . .	2	1	1	1 (without operation)
Parietal . .	1	1	1	0
Cerebellar . .	8	4	4	4 (two without operation)

Röpke,[2] cited by von Bergmann, collected 142 cases of cerebral abscess, 59 of which recovered after operation, and of these over 40% were permanently cured.

[1] *Pyogenic Diseases of the Brain and Spinal Cord.*
[2] *System of Surgery*, vol. i, p. 281.

Delvoie,[1] also quoted by von Bergmann, reports 21 cases of superficial cerebral abscess, acute in nature, with 15 recoveries, and 35 cases of deep and chronic abscess with 19 recoveries.

Ballance[2] collected 26 cases of cerebellar abscess, all of which were submitted to operation, with recovery in 10 and death in 16.

OPERATIONS FOR HERNIA CEREBRI

The protrusion of the brain through a gap in the osseous vault is the direct result of an increased intracranial pressure. To obtain some degree of protrusion is a result desired by the surgeon in the 'decompression' operations carried out for an irremovable brain tumour (see p. 268). A hernial protrusion also occasionally occurs in traumatic affections as the result of hæmorrhage within the skull with its attendant œdema and softening of the brain. Sepsis is, however, by far the most common cause of hernia cerebri, so much so that hernia cerebri is often regarded as implying necessarily a septic condition. Two main causes may be cited for such conditions—abscess of the brain and local or general infection of the brain, the latter state usually arising in connexion with a compound fracture of the vault. In the former case, the abscess must be found and drained, when the protrusion will subside under favourable local and general conditions. In the latter case, desperate measures may be adopted by cutting away the protrusion, in the hope that part of the disease may be removed. Such a course is justifiable, and, indeed, called for, when nothing can be done to treat the cause and when the protruded portion of the brain does not include such cortical regions as are responsible for the more important functions, *e.g.* the motor area.

[1] *System of Surgery*, vol. i, p. 281.
[2] *Cerebellar Abscess secondary to Middle-car Disease.*

CHAPTER VIII

OPERATIONS FOR TUMOURS OF THE BRAIN

Indications. The indications for operation may be arranged in two groups:

Those for radical operation aiming at the removal of the tumour.

Those for palliative operation aiming at the relief of pressure.

For the radical operation. According to Risien Russell,[1] the following are the main indications:—

(i) Cases in which the tumours can be accurately located.

(ii) Cases in which the tumour is situated in an accessible region. The more favourable sites are the surface of the cerebrum, the lateral lobe of the cerebellum, and the 'lateral recess' (cerebello-pontine angle).

(iii) Cases in which there is reason to believe that the tumour is single and of such a nature that it can be removed from its bed. When the nature of the tumour is doubtful, anti-syphilitic remedies are usually and appropriately used. How long such remedies are to be continued is quite another matter. Sir Victor Horsley,[2] in 1890, at the International Congress, urged that a definite probationary period should be agreed upon, and suggested that, in an elementary case where no urgent symptoms like optic neuritis existed, surgical treatment should be employed after thorough medication had been applied for about six to eight weeks without appreciable benefit. No conclusion was arrived at. Allen Starr concludes that the surgeon should be invited to consultation in the case after three months of unsuccessful medicinal treatment. Risien Russell points out that, in some cases of gummatous disease, the administration of anti-syphilitic remedies exercises no result worth speaking of, and, whilst objecting to any time-limit, urges the importance of surgical intervention, each case being judged on its own merits.

(iv) Cases in which there is reason to believe that the removal of the tumour will not greatly imperil the patient's life, and furthermore will not result secondarily in the development of paralysis, aphasia, &c.

For the palliative operation. The following are the main indications for operation:—

(i) To prolong life.

[1] *Brit. Med. Journ.*, October 26, 1907.

[2] Ibid., August 25, 1906.

(ii) To alleviate severe and persistent headache, vomiting, &c.

(iii) To stop the fits.

(iv) To save the sight.

(v) And, in general, to benefit the patient by reducing the intracranial pressure, even though it may be quite impossible to remove or even locate the tumour.

Of all the considerations enumerated above for which palliative measures are indicated there is no symptom which more urgently demands operation than optic neuritis. This question of sight-saving may be accepted as a basis on which to gauge the value of palliative measures in general, insomuch as the indications are equally referable to those other symptoms which result from the increase in the intracranial pressure.

It is obvious that no mere 'decompression' operation is advisable when the optic inflammation has progressed to atrophy, and even in the earlier conditions of the inflammation the cases must be carefully chosen.

Risien Russell[1] draws attention to the importance of differentiating between those cases of optic neuritis which result from toxic tumour products and those which are directly resultant upon the increase of intracranial pressure. In the former case trephining, without removal of the tumour, can give rise to no beneficial results. The difficulty consists in making this differential diagnosis, always a matter of considerable difficulty and usually impossible.

Herbert Bruce[2] admirably clinches this matter in the following words: 'As to the prediction of improvement of vision after trephining, everything depends on the condition of the disks. Yellowish white patches of exudate or white atrophic changes, especially when associated with macular changes, all indicate that the secondary changes in the disks will be permanent. In proportion to this development will the vision be impaired, whilst when the loss of vision has been dependent on the swelling of the disks, then not only is the sight saved but largely improved. In other words, one might say, therefore, that when the neuritis has not progressed on to atrophy the sight would be saved.'

RADICAL OPERATIONS FOR CEREBRAL TUMOUR

Operation. After the usual preparatory treatment and after the exposure of the dura mater, either by craniectomy or by craniotomy (see Chapter II), the question arises as to whether the exposure and removal of the tumour is to be proceeded with at once, or whether it is advisable to postpone further treatment till the patient shall have

[1] *Brit. Med. Journ.*, October 26, 1907.

[2] *Annals of Surgery*, 1907, p. 543.

recovered from the shock attendant upon the dural exposure. The two-stage operation, first recommended by Horsley, is insisted on by some surgeons for all operations performed with the object of tumour removal. By others it is maintained that it is preferable to carry out the operation in one stage, on the ground that two anæsthetics and two operations present a greater risk to the patient's life. Possibly, when the conditions are altogether favourable, it is advisable to complete the operation in one stage, but, as the shock and loss of blood entailed during the first stage is considerable, as the operator cannot possibly foresee with certainty what lies beneath the dura mater, and as considerable time must elapse and considerable hæmorrhage result during the further procedures necessary in the reflection of the dura mater and the removal of the tumour, it follows that it is almost always advisable to conduct the operation in two stages. The second operation can be undertaken a few days later.

Examination of the dura mater. Considerable help may be obtained by examination of the dura, both with regard to the localization of the tumour and investigation as to its nature. Pulsation may be abolished or diminished, and the membrane may bulge outwards in a degree proportionate to the size and site of the tumour. The membrane overlying a tumour may be œdematous or adherent; in colour, it may be anæmic from the pressure exercised upon it, reddened from increased vascularity, grey-brown from the immediate presence of a malignant tumour, plum-coloured from the adjacency of a subdural hæmatoma, or opaque from the presence of a subarachnoid cyst, &c.

Some evidence as to the nature of the tumour may also be obtained by palpation—fluctuation suggesting cyst-formation or hæmorrhage, 'solidity' pointing to the existence of a solid tumour.

Opening the dura mater. No definite rule can be laid down as to the manner in which the dura should be opened. Two methods are adopted —the crucial incision and the flap formation, each of which presents advantages. A crucial incision should generally be adopted. All meningeal vessels must be tied on either side of the proposed line of incision, preferably by means of a fully-curved needle, threaded with fine silk or catgut, passed in such a manner as to avoid puncture of the pia-arachnoid, and without injury to the superficial cerebral veins. The dural incision must always fall short of the margins of the deficiency in the skull by at least $\frac{1}{3}$ inch, in order that accurate approximation may be secured after the removal of the tumour, if such a procedure should be necessary.

An incision is made with a sharp scalpel over the central part of the bulging membrane, and deepened till the pia-arachnoid is exposed. The margins of the dura are then lifted up with fine-toothed forceps, and

the incision completed with the blunt-pointed scissors. If the brain bulges outwards to such a degree that the ready division of the membrane is impeded, a director is introduced beneath the dura and the membrane slit up with the knife.

The dural flaps are then turned outwards and the brain inspected.

Examination of the brain. If the tumour be not visible, further investigation may be carried out by palpation, digital and instrumental exploration, electrical stimulation, and *morcellement.*

Palpation may reveal the presence of a cystic or solid tumour.

Digital and instrumental exploration may be carried out when the surgeon has to deal with a subcortical tumour. This method, however, is not to be undertaken without adopting every precaution to avoid unnecessary damage to the brain substance. The exploration should invariably be preceded by incision with the brain-knife or scalpel, introduced in such a manner as to avoid injury to superficial cerebral vessels, and directed at right angles to the surface of the brain so as to cause the least possible injury to the corona radiata, &c. The margins of the incision are held aside with retractors and the finger gently inserted to find out whether the tumour is removable, further assistance being obtained by the introduction of a flat spatula or periosteal elevator.

Electrical stimulation may be used to see whether the brain exposed by the operation corresponds to the symptoms evinced by the patient. It has been stated that absence of response to the stimulation suggests strongly the presence of a regional subcortical tumour. With regard to the actual technique of electrical stimulation, Cushing[1] writes as follows: 'In the electrical stimulation use a long glass unipolar electrode, carrying a fine platinum core coiled into a spiral at the end, according to Sherrington's plan, in order to obviate the puncture of the pia-arachnoid. The other pole is attached to an extremity, preferably on the homo-lateral side. The current should be just strong enough to contract exposed muscle; some of the fibres of the temporal muscle are generally available for the purpose. If there is abundance of fluid in the sub-arachnoid space, it must be evacuated by pricking the membrane as it spans the sulci of the brain. No motor cortex, unless there is complete degeneration of the pyramidal tracts, fails to give response if these precautions are observed.'

Morcellement, the piecemeal removal of brain substance lying superficial to a tumour, has been recommended for the exposure and removal of cerebellar tumours, especially for such as occupy the cerebello-pontine angle. Under such conditions, *morcellement* of the outer and more superficial portion of the lateral lobe is a perfectly justifiable pro-

[1] *Keen's Surgery*, vol. iii, chap. xxxvi.

cedure. It is a method, however, that should never be undertaken unless considered absolutely necessary.

Extirpation of the tumour. The proportion of brain tumours which are surgically removable is small, probably not more than 20 %. Even when the tumour is fully exposed, considerable experience is needed in determining whether an attempt should be made to remove the tumour or not.

If the tumour be extensive and ill-defined, no attempt should be made to remove it, the surgeon remaining content with having carried out the second desideratum with regard to intracranial tumours in general, namely, the relief of intracranial pressure with consequent alleviation of symptoms.

If, on the other hand, the tumour be circumscribed, whether meningeal, cortical, or subcortical, it may be shelled out of its bed with greater or lesser ease according to its dimensions, nature, and site. The shelling-out process is carried out with the aid of scoop or ordinary teaspoon. Rapidity of manipulation is essential. Hæmorrhage may be arrested by plugging the cavity with strips of gauze.

If highly vascular and surrounded by dilated vessels, with prospect therefore of severe hæmorrhage, the larger vessels should be underrun and ligatured on either side of the proposed line of enucleation. No attempt should be made to clamp the vessels, the fragility of the parts defeating all such measures. In some few cases, it has been found necessary to surround the tumour with a series of ligatures, perhaps interlocked, passed deeply into the substance of the brain. In cases of this nature, the greatest circumspection is needed in determining whether the local conditions warrant an attempt at removal of the tumour.

If a cyst be found, two courses are available: a small cyst may be removed entire; a large one can usually be cured by free removal of the parietal wall, and by supplying adequate drainage.

Closure of the dura and reposition of the flap. When the tumour is readily exposed, and equally readily removed, without hæmorrhage, the dural incision may be closed up, and the scalp or osteoplastic flap replaced. In most cases, however, it will be found necessary to insert a drainage tube. After exposure by craniectomy, the tube can be brought out by means of an incision through the most dependent part of the flap, whilst, in the case of craniotomy, one of the trephine holes, or other suitable part, can be utilized.

Considerable difficulty may be experienced in securing accurate approximation of the dural flap. Assistance may be obtained by elevation of the head, and by restraining the bulging cortex with 'two narrow spatulæ, passed beneath the dura. The two spatulæ are separated like

a pair of scissors during the suturing process, and brought together when withdrawn ' (Bryant).

Some divergence of opinion exists with regard to those cases in which the tumour is not found, or, if found, is not capable of removal. The operation has presumably been carried out with the primary object of tumour removal, and, if such a course be impossible, the surgeon must rest content with an operation which lowers the intracranial pressure and alleviates proportionately the symptoms resulting therefrom. Under such circumstances, no attempt is made to approximate the dural flaps, the hernial protrusion of the brain being restrained by the scalp-flap and by carefully applied bandage-pressure. If the tumour has been exposed by means of an osteoplastic flap, it is usually advisable that the bone should be dissected away from the scalp in order to allow of the required lowering of intracranial pressure.

RADICAL OPERATIONS FOR CEREBELLAR TUMOURS

The cerebellum can be exposed either by craniectomy or craniotomy. It has been stated previously that the formation of the osteoplastic flap is generally contra-indicated in cerebellar operations, mainly owing to the restriction of the field of operation. Craniectomy may be regarded as the operation of choice.

The line of the scalp incision and the site of trephining are the same as when operating for a cerebellar abscess (see Chapter V). After the removal of the disk of bone, the gap is enlarged upwards till the lateral sinus is exposed, forwards to the posterior border of the mastoid process, downwards to the immediate neighbourhood of the foramen magnum, and inwards to near the middle line. This completes the first stage of the operation. In the treatment of cerebellar tumours, the opening of the dura and the search for the tumour should always be postponed for a few days, unless the general condition of the patient is such that immediate relief of intracranial pressure is demanded. After the completion of the first stage the scalp-flap is replaced and fixed in position with a few sutures. At the second stage, the dura is incised and turned down as a flap, the convexity of which falls short of the line of the lateral sinus. All meningeal vessels that cross the proposed line of dural section are first underrun and ligatured.

The cerebellar substance is examined by palpation, inspection, and exploration in the manner described when dealing with tumours of the cerebrum. Greater difficulty is experienced, however, when the operator has to deal with a cerebellar tumour on account of the restriction of the field of operation, the outward bulging tendency of the brain substance, and the danger of sudden respiratory failure from medullary pressure.

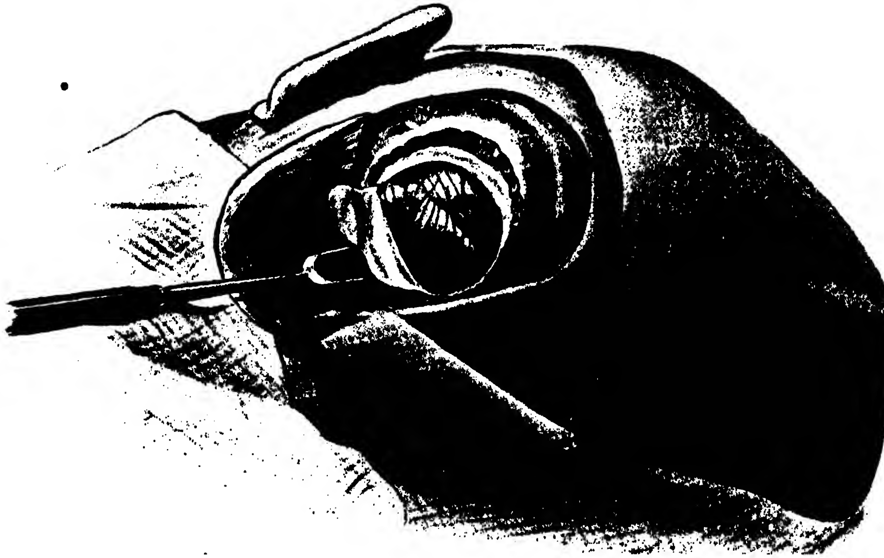


FIG. 136. UNILATERAL EXPOSURE OF THE LEFT HALF OF THE CEREBELLUM BY CRANIECTOMY. The scalp-flap has been turned down and is fully retracted. The cerebellum has been exposed by means of a crescentic dural flap.

FIG. 137. BILATERAL EXPOSURE OF THE CEREBELLUM BY CRANIECTOMY. The left half of the cerebellum has been exposed. The trephine is being applied over the right cerebellar region. Note the position of the trephine and the direction in which it is being applied.

The greatest delicacy of manipulation is required, and every precaution must be taken to avoid unnecessary damage to the soft cerebellar substance.

When the tumour is situated in the region of the cerebello-pontine angle, a somewhat favourite site for tumour formation, 'lateral displacement' of the cerebellum towards the middle line will aid in the exposure thereof. A flat retractor, bent to the suitable curve, is introduced between the dura and the cerebellum, and the lateral lobe of the cerebellum gently and gradually retracted towards the middle line. As the brain yields to the pressure, the tip of the retractor is insinuated forwards towards the posterior surface of the petrous bone. By careful retraction, gentle manipulation, and with the aid of a head-lamp, a view may occasionally be obtained of the lateral aspect of the cerebellum and of the cerebello-pontine angle. Tumours in this region are usually attached by means of a narrow pedicle to the stalk of the fifth, seventh, or eighth pair of nerves. They can usually be removed from their attachment and bed with suitable blunt instruments. The main difficulty arises in

FIG. 138. BILATERAL EXPOSURE OF THE CEREBELLUM BY CRANIECTOMY. The walls of both cerebellar fossæ have been cut away, exposing the bulging dura mater. The Gigli saw is in position for removal of the bridge of bone intervening between the two cerebellar fossæ.

attempting the complete removal of the tumour from the subtentorial space, this being especially the case when the operator has to deal with a tumour of considerable size. No force should be used, and in some cases it may become necessary to remove the tumour piecemeal. The removal of such tumours may be facilitated by the exposure of both lobes of the cerebellum.

The exposure of both cerebellar hemispheres. This operation may be carried out after the manner recommended by Frazier.[1] Each cerebellar

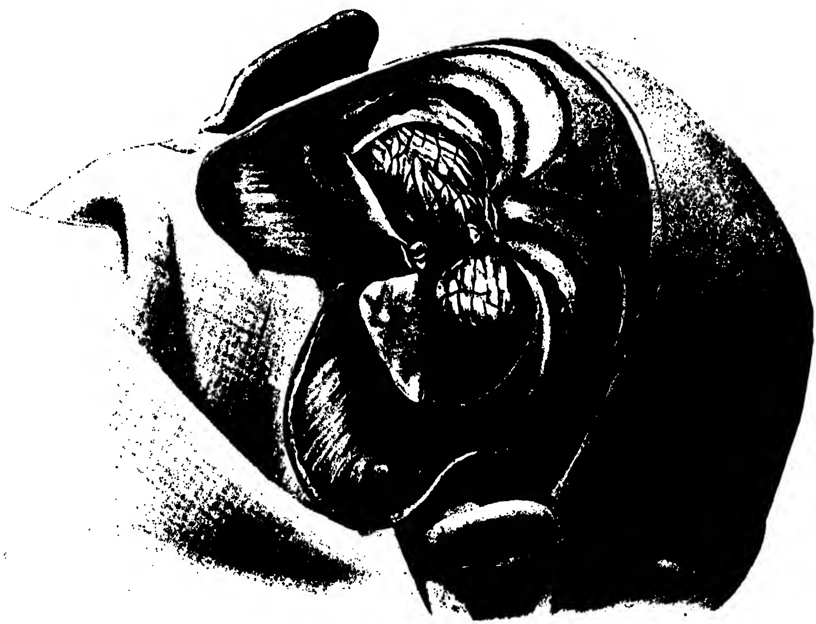


FIG. 139. BILATERAL EXPOSURE OF THE CEREBELLUM BY CRANIECTOMY. The bridge of bone has been removed, two crescentic flaps of dura mater have been turned down, and the falx cerebelli has been ligatured in two places and divided.

fossa is exposed in turn, the scalp-flap being framed, and the trephining and cutting away of the bone carried out in the manner previously described for unilateral exposure. The osseous bridge which separates the two openings in the skull is divided above and below with Gigli's saw, and the intermediate part removed. This completes the first stage of the operation (see Fig. 138).

After the lapse of a few days, the scalp-flaps are again turned down, and dural flaps framed on either side of the middle line, avoiding the lateral sinus above and the occipital sinus in the middle line. The

[1] *New York Med. Journ.*, February, 1905.

occipital sinus is ligatured above and below by means of an aneurysm needle, threaded with catgut, passed around or through the falx cerebelli. The falx is then divided between the ligatures.

The details of the operation are simple to describe. In practice, the difficulties are great, the hæmorrhage severe, and the degree of shock proportionate. The extra space afforded not only allows of the exposure of both halves of the cerebellum, but also permits of the 'dislocation' of one lateral lobe towards the opposite side, thus facilitating the examination of the lateral aspect of the cerebellum and the cerebello-pontine angle.

PALLIATIVE OPERATIONS FOR CEREBRAL AND CEREBELLAR TUMOURS

All palliative operations carried out merely with the object of procuring symptomatic relief may be conducted over the region of the tumour, or over one of the so-called 'silent areas' of the brain, *e.g.* the temporo-sphenoidal lobe. It is obvious that the greatest degree of reduction of intracranial pressure can be obtained by craniectomy, performed over the region of the tumour itself. To this course, however, there are certain exceptions. The precentral or motor area should always be avoided, if possible, for any marked degree of hernial protrusion of this portion of the brain must necessarily result in paralysis, spasticity, &c. In the case of cerebellar tumours also, the subtentorial pressure can undoubtedly be relieved in the most efficient manner by a cerebellar operation, the bone being freely cut away, the dura incised up to the margins of the osseous deficiency, and the cutaneo-muscular flap replaced accurately and firmly in position. This operation presents, however, a great disadvantage, in that the hernial protrusion is often excessive, with disastrous results on the medullary centres.

In the event of the surgeon deciding to attempt alleviation of symptoms by trephining over one of the 'silent areas' of the brain, the operation of choice is that described by Cushing as 'intermusculo-temporal cerebral decompression'. The details and advantages of the operation have already been discussed (see p. 220). When carried out for the relief of pressure resulting from an irremovable brain-tumour, the operative details previously described should be closely adhered to, with the following important exceptions:—

(*a*) After the dura has been incised, no attempt should be made to explore the apex of the temporo-sphenoidal lobe.

(*b*) No drainage tube is inserted, the dural flaps being allowed to lie loosely over the surface of the brain, so allowing of hernial protrusion.

(*c*) The temporal muscle and fascia are sewn up with extra care, thus limiting the degree of hernial protrusion.

With regard to the side on which the operation is to be carried out, it appears that the best results are obtained when the operation is conducted on the same side as that on which the tumour is situated. In the event of failure to procure satisfactory results, a similar operation may be carried out on the opposite side of the head.

Results. Many surgeons have attempted to gauge the value of operation on intracranial tumours, and elaborate statistics have been framed with the object of showing the percentage mortality, cure, &c. Statistics are always fallacious, and this is especially the case with regard to the operations in question. The main reason for this lies in the fact that few surgeons of even considerable experience in cranio-cerebral surgery have operated on a large number of cases, and the statistical tables are therefore compiled from the combined experience of many operators, some of great experience, others possessing but little practical experience, and all adopting those methods which seemed applicable to the particular case in question. Added to this is the fact that there is undoubtedly a tendency to suppress the more unfavourable cases.

The following will serve, however, to give an approximate idea as to the mortality, &c.

Mortality. Duret[1] collected the reports of 400 cases of intracranial tumour. Of these 145, or 36·3 %, died within one month. The cause of death was as follows :—

58 from early shock.
10 from hæmorrhage.
10 from hyperpyrexia.
20 from meningo-encephalitis.
47 from other causes.

Oppenheim[2] reports 371 cases, of which 140 died, either from the operation or within one week of the operation. Mortality, 37·7 %.

Von Bergmann[3] estimates the mortality at 36 %, Knapp at 32 %.

From these records it would appear that the mortality after operations for tumours of the brain can be estimated at 30–40 %. The general technique of brain operations has, however, made great strides during the past few years, and the question of early and accurate diagnosis has received equal attention. In the light, therefore, of the most modern experience the mortality can be estimated at a considerably lower percentage. Certain other factors in the case also require consideration.

[1] *Les tumeurs de l'encéphale.*
[2] *Tumours of the Brain,* 1902 (Nothnagel's System).
[3] *System of Practical Surgery,* vol. i.

The mortality according to the region affected. The following table supplies information as to the mortality according to the regional situation of the tumour. The cases were collected by Knapp.[1]

Frontal . .	32 cases . . .	Mortality	25 %.
Central . .	231 „ . . .	„	23 %.
Parietal . .	29 „ . . .	„	41 %.
Temporal . .	17 „ . . .	„	29 %.
Occipital . .	10 „ . . .	„	20 %.
Cerebellar . .	54 „ . . .	„	45 %.

Sir Victor Horsley[2] draws attention to the influence of the region of the skull opened, and states that 'if a line be drawn from the frontal eminences to the occipital protuberance, it is obvious that more shock results from operations below that line than from above, and, also, as we proceed from the frontal to the cerebellar pole of the encephalon'.

The mortality according to whether the tumour is found or not, or found but not removed. Data are also supplied by Horsley[2] which enable us to determine the increased risk to the patient in operating without a correct diagnosis, and in exploring for a tumour which is found to be irremovable. Thus, of 79 cases in which a correct diagnosis was made and the tumour removed, 7 cases died from shock; whilst in 16 cases inaccurately diagnosed, 6 died—a mortality of 8 % in the first case, as against 37 % in the second.

Frazier[3] draws attention to the same point, exemplifying his statement by showing that in cerebellar cases death occurred, when the tumour was found and removed, in 12·9 % cases, whilst, when the tumour was not found, the mortality was 26·7 %.

The increased risk to the patient's life after an unsuccessful attempt to remove the tumour must not be advanced as an argument against the palliative measures previously alluded to, for the failure to find a tumour implies diligent search for the neoplasm, with necessary prolongation of operative procedures and manipulation of brain substance. The statistics, however, clearly establish the fact that accurate localization of the tumour is essential for the success of the radical operation.

[1] *Boston Med. and Surg. Journ.*, 1906, p. 124.
[2] *Brit. Med. Journ.*, August 25, 1906.
[3] *New York Med. Journ.*, February, 1905.

CHAPTER IX

OPERATIONS FOR HYDROCEPHALUS INTERNUS: OPERATIONS FOR CEPHALOCELES

OPERATIONS FOR HYDROCEPHALUS INTERNUS

Indications. Hydrocephalus internus may be congenital or acquired: in the former case, the pathology is obscure, and doubt exists as to whether the ventricular distension arises from primary changes in the ventricular ependyma or from obstruction to the outflow of cerebro-spinal fluid from the fourth ventricle. Acquired hydrocephalus results from the presence of a subtentorial tumour, from thickening of the membranes in the region of the foramen of Majendie, and from other known causes. The results of operation are not sufficiently satisfactory to enable the surgeon to urge operative interference until medicinal and other remedies have been tried and found wanting. No fixed probationary period can be laid down as a guide, but it is perfectly clear that the surgeon cannot possibly carry out operation with benefit to the patient if the ventricular distension is allowed to progress to such a degree that marked cortical flattening and degeneration result. Surgical treatment to be efficacious must be undertaken at an early stage of the disease.

Operation. Operations are carried out (*a*) with the object of withdrawing fluid from the distended ventricular spaces (ventricular puncture), and (*b*) to establish a communication, or short-circuit, between the ventricular and cerebral subarachnoid spaces (ventricular drainage).

Ventricular puncture is indicated in congenital cases, whilst ventricular drainage is called for in acquired hydrocephalus and in those congenital cases in which improvement after repeated puncture ends in relapse.

Ventricular puncture. This may be carried out through the anterior fontanelle, through the frontal bone, or over the descending cornu of the lateral ventricle.

(*a*) *Through the anterior fontanelle.* The region of the fontanelle is shaved and cleansed in the usual manner, after which the surrounding parts are cut off from the field of operation by the application of a sheet of gauze or lint, in which a hole is cut sufficing to allow of the exposure of the site of election for puncture.

The patient should be in the recumbent position, the head well towards the end of the table and turned slightly towards the side on which the operation is to be carried out. The operation can be performed without an anæsthetic or under local anæsthesia. The ventricle can be tapped with either a small trochar and canula or syringe. The former instrument is preferable. A site is chosen at the outer angle of the fontanelle, about ¾ inch away from the median antero-posterior line, thus avoiding the line of the superior longitudinal sinus. The evacuating instrument is passed directly inwards, towards the base of the skull, for a distance of not more than 2 inches. The trochar is withdrawn, and the fluid allowed to escape. If the cerebro-spinal fluid escapes at high pressure, the flow should be regulated with the finger placed over the mouth of the canula, and, in any case, it is inadvisable that more than 50 cubic centimetres should be allowed to flow away at any one sitting. The effect of the withdrawal of the fluid must be carefully noted, and at any sign of collapse on the part of the patient the outflow must be stopped at once. After withdrawal of the canula, the site of tapping is covered with collodion gauze, maintained in position by strapping. Subsequent bandaging of the head (preferably with an elastic bandage) may assist in preventing the reaccumulation of fluid. Although the condition of the patient shows improvement after ventricular puncture, the operation usually requires to be repeated several times before material benefit results.

(*b*) *Through the frontal bone.* When the anterior fontanelle is closed the ventricles may still be tapped from above. Tillmanns,[1] in recommending this procedure, writes, 'The needle should be inserted about 2 centimetres from the central line and 3 centimetres from the precentral sulcus. You strike the ventricle at a depth of from 3 to 5 centimetres.' Trephining is usually necessary as a preliminary measure.

(*c*) *Over the descending cornu of the lateral ventricle.* This operation possesses one great advantage in that efficient drainage is supplied. It is strongly advocated by Keen. A point is mapped out on the skull which lies 1½ inches behind the external auditory meatus and the same distance above Reid's base-line (see Chapter I). A bradawl is introduced at this point so as to indent the external table of the skull. A small scalp-flap is then framed, suited to the region to be explored. The pin of the trephine is applied to the indicated spot, and the disk of bone removed. The posterior branch of the middle meningeal artery ramifies in the immediate neighbourhood, and due care must be taken to avoid injury to this vessel. After the exposure of the dura mater, the trochar and canula are introduced through the dura, directed towards the

[1] *Brit. Med. Journ.*, October 24, 1908.

summit of the opposite ear, and passed for a distance of not more than 2 inches. The cerebro-spinal fluid is allowed to escape with precautions similar to those enumerated above. The disk of bone should not be replaced. The scalp-flap is sewn into position. If a second puncture should be required, the syringe can be introduced without difficulty through the scalp and trephine hole. When the lateral fontanelles are open, the evacuating instrument can be inserted without previous trephining.

Ventricular drainage. Drainage of the lateral ventricles is carried out to the best advantage by first adopting *Keen's*[1] method of ventricular puncture. The diagnosis being confirmed, the gap in the skull is enlarged up to a diameter of 1 to 1¼ inches, and the dura incised crucially, the dural incisions being carried to within a short distance of the margins of the gap. The trochar and canula are now introduced into the lateral ventricle and some 50 cubic centimetres of cerebro-spinal fluid allowed to escape. A few strands of catgut, tied together in the form of a bundle, are then passed through the canula in such a manner that the distal ends project into the ventricular cavity, whilst the proximal portion is tucked either into the subdural, extra-dural, or subaponeurotic spaces. Drainage into the subaponeurotic region tends to convert the state of internal hydrocephalus into one of cephalocele, whilst extra-dural drainage seldom permits of sufficiently rapid reabsorption of the cerebro-spinal fluid. Undoubtedly, subdural drainage allows of the best results. In this method, the proximal ends of the catgut are insinuated between the brain and the dura mater. The dural incision is sewn up, and the scalp-flap replaced.

More recently, a method has been adopted, and in some few cases with encouraging results, in which tubes of decalcified bone were substituted for the catgut bundle. This change was recommended after it had been found that the absorption of the catgut and the falling together of the brain substance usually prevented the formation of the fistulous channel between the ventricular and cerebral cerebro-spinal spaces.

Burghard uses decalcified bone tubes in the following manner: An ordinary tube is cut obliquely through its central part, and the two halves sewn together with catgut in such a manner that they lie at right angles to one another. The tube is then introduced so that one segment projects into the lateral ventricle, the other into the subdural space. Accurate approximation of the dura mater is desirable in order to limit the escape of cerebro-spinal fluid, a troublesome complication. An attempt should therefore be made to sew up that membrane, though this is always a matter of considerable difficulty.

[1] *Surgery. Its Principles and Practice*, vol. iii.

The bone tubes will be absorbed in the course of time, but, it is hoped, after the formation of a fistulous channel between the ventricular and cerebral cerebro-spinal spaces.

OPERATIONS FOR CEPHALOCELES

Under the definition 'cephalocele' are included all those cases in which, as the result either of trauma or of congenital deficiency in the formation of the vault and base of the skull, there is a gap in the skull through which the membranes alone (meningocele), or membranes and brain (meningo-encephalocele), outwardly bulge.

OPERATIONS FOR CONGENITAL CEPHALOCELES OF THE VAULT AND BASE OF THE SKULL

Indications. According to the late Professor von Bergmann,[1] the indications for operation are as follows :—

(i) Inoperable cases :

Those associated with premature synostosis and microcephaly.

Those associated with hydrocephalus or marked deformity.

Those in which the tumour is situated below the external occipital protuberance.

(ii) Operable cases :

Limited protrusions with none of the above defects and disadvantages.

These indications may be accepted as affording a general basis on which to estimate the feasibility of operation. Each case, however, must be considered on its own merits, and no case must be dismissed as inoperable without the fullest investigation. For instance, those cephaloceles which are situated below the external occipital protuberance are included in the inoperable class because it has been found that the osseous defect in the occipital bone sometimes extends into the foramen magnum, because such cephaloceles are occasionally complicated by a condition of cervical spina bifida, and because the sac of the hernia sometimes contains a portion of the cerebellum itself. Such conditions are, however, by no means the rule, the cephalocele not infrequently possessing but a narrow pedicle and only communicating with the interior of the subtentorial space by means of a narrow channel. The mere fact also that the sac contains neuroblastic elements does not by any means imply necessarily that those elements are of vital importance to the individual. Lyssenkow[2] pointed out that these cephaloceles are in reality of the nature of teratoid tumours, a fusion of epiblast and mesoblast, and that it is the

[1] *Beiträge zur klinischen Chirurgie*, vol. vii, p. 228.

[2] *Der Hirnbruch und seine Behandlung* (Dissert. Moskowa, 1906).

exception rather than the rule for a cephalocele not to contain some material of neuroblastic origin.

It must also be borne in mind that, without operative interference, the case is almost necessarily fatal, although, now and again, more favourable results are reported.

Insomuch also as the tumour generally tends to increase in size, thus still further widening the gap in the skull, the operation should be carried out as soon as the surgeon is satisfied that the general condition of the patient warrants such interference.

Operation. The unhealthy condition of the overlying integument, especially at the apex of the tumour, prohibits any extensive preparatory cleansing, this process being carried out for the most part when the child is under the anæsthetic.

Scalp-flaps are framed from the region of the base of the tumour, advantage being taken of the more healthy integument. These flaps must be so sized and framed that accurate approximation and complete protection to the gap will be subsequently attained. The flaps are dissected back to their base. The pedicle of the tumour is defined and an endeavour made to detach it completely from the margins of the osseous defect. This is usually a matter of considerable difficulty. The sac of the tumour should then be tapped with trochar and canula, and the fluid contents allowed to escape slowly, after which the membranes are slit up towards the base of the protrusion with blunt-pointed scissors.

When dealing with a pure meningocele, the membranous protrusion is cut away in such a manner as to leave merely sufficient tissue to allow of closure of the dural gap. This closure can either be carried out by means of a purse-string suture, or by the union of two lateral flaps. In either case, accurate approximation is essential in order to prevent as far as possible the escape of cerebro-spinal fluid.

If the sac should contain an irregular mass of neuroblastic material, apparently not true cerebral or cerebellar substance, this material can be dissected from the membranous sac, ligatured at the base, and freely cut away.

If the sac should contain true brain substance, the possibility of excision can be raised. In the cerebellar region such measures are contra-indicated, and the surgeon must remain content with an attempt at replacing the cerebellar substance within the cranial cavity. This reposition will be aided by elevation of the head and by lumbar puncture. If the protrusion corresponds to a region which has no known motor function, it may be cut away with the scalpel flush with the bone. The hæmorrhage may be considerable, but can be controlled by pressure,

by irrigation with hot water at a temperature between 110° and 115° F., by the cautery, and by ligature of bleeding points. When bleeding occurs, a drainage tube should be inserted. Shock is often very severe, and these radical measures must not be lightly undertaken.

To remedy the osseous defect, Lyssenkow[1] recommends an osteoplastic operation, turning down from the skull above the defect a flap which comprises the pericranium and the external table of the skull. The flap is so turned down that the pericranial surface becomes internal, the fragment of bone being suspended by the continuity of the pericranium. He reports 72 cases so treated, with 37 recoveries and 35 deaths.

König and von Bergmann[2] oppose this osteoplastic method on the ground that the extreme thickness of the skull does not usually allow of the splitting off of the external table, and that, even when such a course is feasible, the fragment undergoes necrosis.

Transplantation of calcined and decalcified bone, silver, and celluloid plates have all been tried with no great degree of success. Smoylenko proposes paraffin or vaseline injections, especially for the naso-frontal variety of cephaloceles.

When the surrounding bone is of such a nature that it is possible to form an osteo-plastic flap, this measure should be adopted. In other cases, it appears preferable that no immediate attempt should be made to remedy or protect the gap in the hope that nature will repair the defect in part, the surgeon aiding the process at a later date by carrying out one of the measures advocated for the protection of gaps in the skull (see Chapter VI).

OPERATIONS FOR TRAUMATIC CEPHALOCELES

Indications. Though traumatic cephaloceles are comparatively of rare occurrence, yet sufficient data are at hand from which to formulate certain points with regard to the question of treatment. The patients are usually in the first three years of life, the protrusion is commonly placed over the right parietal bone, and it develops within two or three weeks of the accident. The fracture is simple in nature, the bone fissured, and the dura torn, whilst through the membranes and osseous gap the congested and œdematous brain bulges outwards.

Operation. For the remedying of this condition three courses are available:

Aspiration and puncture. The tumour is tapped with the trochar and canula or syringe, and the fluid contents withdrawn. Little benefit

[1] *Der Hirnbruch und seine Behandlung* (Dissert. Moskowa, 1906).
[2] *System of Pract. Surg.*, vol. i.

results, as the tumour is mainly composed of brain substance. It is barely necessary to state that injections of irritating fluids are condemned absolutely.

Exposure by open operation, followed by reduction or removal of the herniated brain substance. The operative details closely resemble those described previously when dealing with congenital cephaloceles. The local conditions are, however, in this case less favourable. There is a considerable defect in the bone, and the margins of the gap are almost invariably thinned and everted. The site of the protrusion also usually prohibits the removal of the herniated brain substance.

Expectant treatment, combined with the application of pressure. The surgeon is compelled as a rule to adopt this third alternative.

Results. In a series of 37 cases collected by the writer,[1] the following results were obtained :—

An open operation was carried out in 5 cases, with 2 recoveries and 3 deaths.

Aspiration resulted in 13 recoveries and 9 deaths, the high mortality being mainly due to the fact that operative measures were carried out in a considerable number of cases before the days of aseptic surgery. An expectant attitude was adopted in 9 cases, with 8 recoveries and 1 death.

The term 'recovery' merely refers to the early result obtained. A complete recovery, with recession of the brain and complete closure of the gap in the skull, must be regarded as of excessively unlikely occurrence. The majority of cases die within a few months of the accident.

[1] *St. Barts. Hosp. Reports*, vol. xl.

SECTION III

OPERATIONS UPON THE CENTRAL NERVOUS SYSTEM

PART II

OPERATIONS UPON THE SPINAL CORD AND CANAL

BY

W. THORBURN, F.R.C.S. (Eng.)
Surgeon to the Manchester Royal Infirmary

CHAPTER X

OPERATIONS FOR SPINA BIFIDA

Indications. The term spina bifida includes all forms of congenital cleft of the coverings of the spinal cord as well as many malformations of the cord itself, so that cases range in severity from the simplest forms of meningocele, which may even undergo spontaneous cure, to the most severe deformities of the nervous system, which are incompatible with life and insusceptible of useful treatment. In many it is impossible to operate with any hope of cure, and it is probable that many, if not most, of the cases will never come within the reach of surgery. On the other hand, very satisfactory results may be obtained by a judicious selection of cases and adaptation of the operation to the conditions, so that we are at the outset principally concerned with the selection of cases for operation and the selection of the method of operation.

In connexion with the *tumour* we shall be guided principally by its size, the condition of its coverings, and the amount and nature of its nervous contents. The most satisfactory cases are those in which the projection is small and stationary in size, or with very slight increase or decrease, while the coverings are intact and quite free from ulceration, and the sac has few nervous contents or none at all. Departures from this type render the results of operation less hopeful, and extensive ulceration of the cutaneous covering, perforation of the sac with leakage of cerebro-spinal fluid, or the presence in the sac of much nervous tissue, whether in the form of a meningo-myelocele or of a syringo-myelocele, will make success highly improbable.

Age is a factor of much importance. On the one hand, all the more radical operations are associated with considerable shock, so that it is advisable, when possible, to defer them until the end of the first year of life or even later. On the other hand, it is during the first year that the majority of cases die from ulceration and sepsis or from other causes, and thus considerable danger is again incurred by waiting, while the development of function after reposition of nervous structures is much more likely to be secured if the operation be performed early. It will, therefore, largely become a matter of judgment in each individual case how early an operation is to be performed. Other things being equal, the earliest

date should certainly be chosen, but the general condition may render delay essential at all costs, while in the case of very young children the operation should be the simplest and most rapid which is likely to preserve life. It may also be possible to temporize by occasional aspiration of the sac, and thus to defer a more radical operation until the attainment of a safer age.

Distinct *hydrocephalus* is a definite contra-indication to operation, and has in many cases been rendered much worse thereby, but slight hydrocephalic conditions need not deter us and are not incompatible with spontaneous or post-operative recovery. Severe *paralysis* of the lower limbs generally indicates an amount of injury to the nervous structures which will render all operations futile, and such paralysis has even been aggravated by operation:

Cases may then be classified somewhat as follows :—

1. Suitable for operation.

(i) Sacs of moderate size, or comparatively slow growth, with few or simple nervous connexions, and with intact or comparatively healthy coverings.

(ii) Cases which remain stationary, or which, after spontaneous retrogression, cease to improve.

2. Unsuitable for operation :

(i) Cases presenting small tumours with intact skin and marked tendency to contract, many of which recover spontaneously.

(ii) Large sacs with leaking contents or widely ulcerated surfaces, in which sepsis will almost certainly follow any interference.

(iii) Cases of marked general marasmus or severe hydrocephalus or paralysis of the lower limbs.

Spina bifida occulta and the cicatrices of old and healed spina bifida will be considered in connexion with the operation of laminectomy.

Choice of operation. The choice of method will lie in the first instance between injection of the sac and excision of the sac, the older methods of simple puncture, ligature, drainage, and galvano-puncture being too dangerous and unreliable to merit consideration, except in so far as simple aspiration may be used as a temporary measure in cases unsuitable for curative operation.

INJECTION OF THE SAC

Injection was widely practised some years ago, but as compared with excision it is decidedly less certain in its results, although undoubtedly more easily and rapidly performed and associated with less shock. Excision may therefore be regarded as the preferable operation in all cases in which it can be adopted.

Indications. Injection may still be employed—

(i) In urgent cases in which the age of the child forbids more elaborate measures.

(ii) In the case of rapidly growing sacs with ulcerated coverings, and possibly

(iii) In cases in which there is much extrusion of nervous contents, although in the latter the injection has occasionally been followed by an aggravation of the paralysis.

Operation. The only *instrument* required is a small syringe capable of efficient sterilization, with a needle, preferably of platinum and having a calibre sufficient to allow of the ready flow of glycerine. Various *fluids* have been used for the injection, and most of these contain iodine as their active principle, the best being the iodine and glycerine mixture of Morton, which consists of 10 grains of iodine, 30 grains of potassium iodide, and 1 ounce of glycerine, the glycerine preventing unduly rapid diffusion of the fluid when injected into the sac, and the potassium iodide acting as a solvent.

The tumour and surrounding skin having been thoroughly cleansed, the child is anæsthetized with chloroform and placed on its side with the head low, so as to diminish the pressure of fluid in the sac. The cyst is then punctured with the needle, and if it is very tense, it is advisable to allow a small amount (1 or 2 drachms) of the contents to escape before injecting the fluid. In many cases, however, the latter may be injected at once without any preliminary withdrawal of the contents of the sac. The puncture should not be made in the middle line, and it is important to avoid any umbilicated areas, as these generally indicate the attachment of nerve structures to the sac. If the sac be extremely thin, the danger of leakage through the puncture may be still further reduced by pinching up a fold of healthy skin at the side of the tumour and thrusting in the needle at this point, so as to enter the cyst laterally, after having traversed the subcutaneous tissue for some distance. From half to one drachm of the fluid is then injected, and on withdrawal of the needle the puncture is at once closed by a seal of collodion and gauze. A layer of cotton-wool and a bandage complete the dressing.

After-treatment. The child should be kept on its side for the next few hours in order to diminish the pressure of cerebro-spinal fluid within the sac, but after this interval it should lie upon its back for a few days to obviate the flow of the irritant fluid from the sac into the spinal canal. It is also necessary to cover the tumour with cotton-wool so as to avoid all pressure and friction.

In a successful case the sac will thicken, lose its translucency, and gradually shrink, the ultimate result of one injection being obtained in

ten or fourteen days, after which the process may be repeated, several injections being usually required before a cure is obtained. In other cases little or no result will be obtained, and, again, in others there may develop signs of acute inflammation with rapid increase in the size of the sac, which is liable to be followed by leakage and fatal meningitis. Lastly, the operation may be quite successful in causing contraction or obliteration of the sac, but death may follow from the rapid development of hydrocephalus.

Results. It is difficult to obtain trustworthy statistics as to the results of treatment by injection. A committee of the Clinical Society collected 71 cases (*Trans. Clin. Soc., London,* 1885, vol. xviii, p. 338), of which 35 recovered, 27 died, 4 were relieved, and 5 unrelieved. Owing to the tendency to report successful cases, these figures, however, probably give too hopeful a view. In a series of 12 cases treated at the Manchester Children's Hospital and collected for me by Mr. E. D. Telford, 3 were cured, 8 died, and 1 was unchanged, results which, although fewer in number, are probably more accurately representative of the truth.

EXCISION OF THE SAC

Indications. Excision of the sac with or without plastic closure may be regarded as the operation of election and should always be adopted when practicable. It is, however, unsuitable for children under one year of age, as the shock involved is considerable, and it necessitates a fairly good condition of general nutrition. Yielding the best results in simple meningoceles, especially in those with a narrow pedicle and *a fortiori* in those in which the pedicle is imperforate, it may also be adopted in myelo-meningocele, although in the larger and more complex forms the results are disappointing. In syringo-myelocele this, in common with all other treatment, is probably useless. Extensive ulceration, leakage of cerebro-spinal fluid, hydrocephalus, and extensive paralysis are, however, absolute contra-indications to excision, although small areas of ulceration which can be disinfected and excised need not debar from operation.

Operation. The *instruments* required are a small scalpel, scissors, dissecting forceps, fine toothed forceps, pressure-forceps, wire retractors, a blunt dissector, and a probe ; a strabismus hook is useful for the retraction of nerve trunks. Fine curved intestinal needles with holder and chromicized catgut are used for the deeper sutures, and for the skin sutures silkworm-gut or horsehair.

The operation presents several distinct stages, not all of which may be required, *viz.* (1) the excision of thinned or ulcerated skin and reflection of two flaps of healthy skin, (2) the evacuation of fluid contents and

excision of the expanded meninges, (3) the replacement in the spinal canal of extruded nervous tissues, (4) the watertight closure of the gap in the soft parts. Further proceedings, if adopted, may be described as ‘ plastic ’ operations.

The child is anæsthetized with chloroform and placed on its face with the head low to guard against loss of cerebro-spinal fluid. Warmth and a thick swathing of cotton-wool should be used to minimize shock, and it may be advisable in the case of very large sacs to gradually diminish tension by previous aspiration for several days before the radical operation (Reid, *Med. Record*, Oct., 1899). The tumour and adjacent skin are cleansed, and any patches of ulceration present should be touched with some strong antiseptic such as pure carbolic acid, and removed as early as possible in the operation.

In rare cases, in which the whole of the cutaneous covering is of good thickness, it may be possible to reflect this as a single flap, preferably from above downwards, a single incision round the upper half of the tumour being used for this purpose.

Far more commonly two curved incisions will have to be made over the more prominent part of the tumour so as to include between them a spindle-shaped area of the thin cutaneous covering. These incisions unite above and below, and should include between them any skin which is too thin to heal afterwards, but it is essential that they should leave on their outer sides enough sound skin to cover over the gap without the slightest tension, and, if this cannot be done, it may be necessary at a later stage of the operation to make other lateral incisions outside of the original one so as to allow of gliding inwards of two cutaneous bridges (see Fig. 140). In the majority of cases the elliptical area of excised skin will have its long axis vertical and in the middle line as in the drawing, but where the sac is very low down it may be useful to make the incisions horizontal so that the wound may not encroach too nearly upon the cleft of the nates, where it is in danger of being soiled. It is also advisable, in all cases where there is a sufficient amount of sound skin to leave any choice to the surgeon, to make the incisions in such a way that one lateral flap is larger than the other, so that the final line of suture will lie to one side of the middle line ; the deeper incisions can then be placed to the opposite side, the covering layers thus overlapping, and the risk of leakage being greatly diminished.

The lateral flaps of skin and subcutaneous tissue thus marked out by the two incisions are next carefully dissected or peeled outwards from the sac, great care being necessary to avoid sudden rupture of the latter, as the rapid escape of cerebro-spinal fluid may cause severe shock. When the sac has thus been thoroughly cleared it must be carefully examined,

and the nature of its contents and attachment to the spine should be fully investigated. It will then be ascertained whether the tumour is a simple meningocele with a narrow or wide neck, or whether it contains nervous structures.

In the case of simple meningocele with a narrow neck it now suffices to ligature the latter, and after cutting off the sac to close the skin wound over the stump. If the neck be at all wide, or if there be any contents other than fluid, it will, however, be necessary to proceed with the opening of the sac and a careful dissection of the deeper parts.

In the majority of cases the sac will thus require to be opened, and it will often be found to contain various structures the return of which to the spinal canal is essential. It is in connexion with this portion of the operation that its principal dangers—shock from profuse flow of cerebro-spinal fluid or interference with nervous structures, and meningitis — arise, and great caution should therefore be used to avoid a sudden escape of its contents. Before making the opening, the upper end of the sac should be compressed with gauze to prevent a gush of fluid from the spinal canal. A minute opening is then made to allow of the gradual escape of the cerebro-spinal fluid, after which it is converted into a free incision. The latter incision must not be placed in the middle line, and must avoid any depressed areas in which it is likely that nerve tissue is adherent. It should also be planned in such a way that the line of meningeal suture is lateralized and removed as far as possible from the line of skin suture, and this can be done more effectively in the deeper incision of the meninges than in the skin, in which little latitude will be possible in the formation of flaps.

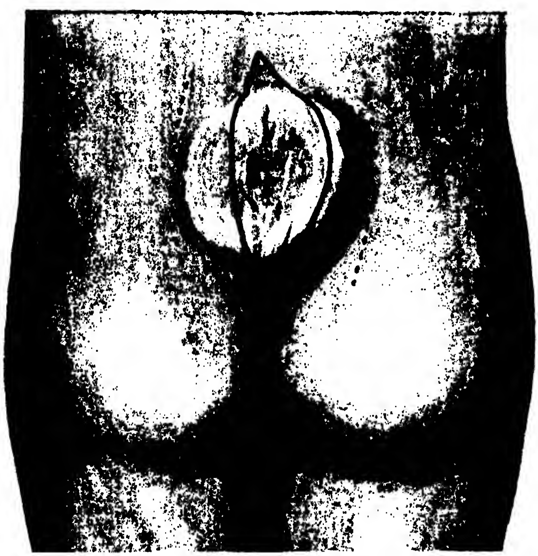


FIG. 140. SPINA BIFIDA. *Incisions for excision of the sac.* The dotted lines indicate the incisions which may be required to allow approximation of the flaps.

When a free incision has been made, nervous contents will again be

sought for and, if present, dealt with, but if there are no such contents the redundant sac is now cut away and the meninges closed by a continuous suture of fine catgut, great care being taken to leave a sufficient margin to allow of suture without tension.

The disposition of the nerve structures inside the sac varies much, the most useful classification from an operative point of view being that given by Chipault (*Chirurgie Opératoire du Système Nerveux*, 1895, vol. ii, p. 10), who describes the following types :—

1. The nervous tissue may be spread over the inner surface of the sac. There may be found—

(i) A thin layer of medullary matter spread over the whole inner surface of the sac.

(ii) The spinal cord, more or less atrophic, may be adherent to the sac in the middle line, whilst the nerves arising from the involved stretch of cord are adherent to the sac-wall as they pass to their foramina of exit.

(iii) The spinal cord may be normal, but has contracted secondary adhesions to the sac. The nerves arising from it are adherent as in (ii).

2. The nervous elements are confined entirely to the middle line of the sac, and the nerve trunks, instead of running round its walls, pass straight across it to their exit.

3. There are no nervous elements within the sac, except bands stretching backwards into it from the spinal canal. These bands are of very different types and values: they may represent the cord itself, or perhaps a much enlarged filum terminale; whilst in some cases the band consists only of a large nerve which ends in the supply of the sac itself.

The separation of these structures is often a matter of great difficulty. They must be most carefully isolated from the sac with a blunt instrument, and where their adhesions appear very tough it is advisable to return a small portion of attached sac with the nerves rather than to prolong unduly an operation in which rapidity is essential to success. It is also of essential importance that none of the bands entering the sac should be cut across until the operator has satisfied himself that they do not leave it again at a lower point. When all the structures have been freed they should be gently returned within the spinal canal, and, the redundant sac having been cut away, the gap in the meninges is closed as usual by a continuous suture of fine catgut. If it be thought inadvisable to prolong the operation by any more elaborate attempt to deal with the defect in the spinal column the skin wound is now closed. No drainage should be used, and it is well to employ mattress sutures so as to obtain a broad ridge of apposition, followed by accurate closure of the epithelial

edges with a continuous suture. In cases of great tension this may be further relieved by passing the deep or mattress sutures round two pieces of rubber tubing (Stiles, *Brit. Med. Jour.*, 1902, vol. ii, p. 673). The best dressing is a seal of collodion and gauze covered by aseptic wool, which should be frequently renewed. For some days after the operation the child should lie upon its face with the head low, as there is here no irritant fluid to flow from the sac, and we have only to guard against the flow of cerebro-spinal fluid into the wound.

Plastic operations. Many surgeons limit the operation to excision of the sac with suture, and consider any further interference unnecessary and unjustifiable, but there is no doubt that in suitable cases a more perfect result may be attained by methods which aim at occluding the bony defect in the spine. The advantage to be thus gained from the lessened risk of leakage and the provision of a firmer scar should, however, be held to justify the performance of a plastic operation only when the local condition of the cleft and the general condition of the child permit a prolongation of the operation.

The nature of the plastic operation will be determined by the size of the opening, and especially by the condition of the rudimentary laminæ which bound its sides, the methods which have been employed or suggested being conveniently arranged in three groups.

On the soft parts. The simplest form of this operation consists in *utilizing the sac as a plug* to close the gap in the spinal canal. After it has been cleared and opened, and its contents dealt with, it is closely folded upon itself and, instead of being excised, is fixed in the opening by a few points of suture; the skin wound is then closed in the usual manner.

A more satisfactory method consists in raising *flaps of the adjoining muscular and aponeurotic structures*, drawing these inwards and suturing them across the opening. After the sac has been cut away and sutured, the skin flaps are raised so as to expose the vertebral aponeurosis for a distance of about 1 inch on either side of the opening in the spine. A deep vertical incision is then made on each side parallel to the middle line, and a stout bridge of aponeurosis and muscle is raised off the bones by blunt dissection, as in raising the muco-periosteal flaps for the ordinary operation of staphylorrhaphy—the two bridges, attached above and below, being freed sufficiently to enable them to meet in the middle line without tension. They are then brought together over the cleft and closely united by suture, while it is advisable to rotate them slightly on their long axes so that they are approximated by their deep or muscular surfaces and form, when united, a strong crest over the opening. The skin flaps are then replaced and closely sutured as before. This operation yields a strong thick covering, and probably affords effective protection;

in the sacral region the bridges of tissue contain aponeurosis only, but this is strong and provides a firm fibrous covering.

With osteoperiosteal flaps. A still more perfect closure of the spinal defect may be obtained by the formation and approximation of osteoperiosteal flaps, and if the laminæ bounding the cleft are not in an altogether rudimentary condition, they undoubtedly supply the best material for the closure of the cleft. To obtain such closure in the dorsal and lumbar regions the laminæ on each side of the opening are cleared of their overlying soft parts, without being stripped of periosteum or separated from one another, and they are then divided with bone-cutting forceps as far outwards as possible at their junction with the pedicles and articular processes. There is thus raised on each side a bridge, containing the detached laminæ with their intervening ligaments, which is fixed to its fellow of the opposite side as in the case of the musculo-aponeurotic bridge above described, silver wire sutures being useful for this purpose.

Bobroff (*Centralblatt für Chirurgie*, 1892, p. 465) has carried out a similar manœuvre in the case of sacral defects. The gluteus maximus of one side is first raised from the ilium and carried outwards from that part of its origin adjacent to the cleft. A portion of the iliac bone, 1 centimetre in thickness and large enough to cover the spinal cleft, is then raised with a chisel or gouge from the posterior part of the iliac crest, but its periosteum is left uninjured at the inner side of the plate, and constitutes a hinge about which the fragment is turned over and inwards so as to cover the deficiency in the middle line. Bobroff also suggests that a similar procedure could be employed in cases of spina bifida of the dorsal region, in which laminar flaps could not be obtained, by stripping an osteoperiosteal flap from the ribs and utilizing it to cover the deficiency in the column. This modification of the method would, however, involve extensive separation of muscle in order to bring the flap to its destination by the shortest route, and it does not appear to have been actually adopted.

Involving the grafting of foreign bone and other substances. Lastly, various attempts have been made to close the spinal defect by the introduction of plates or strips of foreign bone or periosteum, or even of other materials. Such methods present the objections which are inseparable from all bone-grafting operations, but they have here the great advantage that they shorten the time of the operation, as the material to be implanted can be prepared before the operation is commenced, and the latter is therefore not more serious or more difficult than simple excision of the sac. Thus it is only necessary to resect and suture the sac, and at once to superimpose a thin layer of prepared material (bone, periosteum, or celluloid), holding it in position by a few sutures and closing the skin over it.

For the purposes of the graft, Mayo Robson (*Brit. Med. Journ.*, 1883, vol. i, p. 558) has used strips of periosteum from the femur and frontal bone of a freshly killed rabbit, and other surgeons report successful cases in which small fragments of rabbit periosteum were simply scattered over the exterior of the sutured meninges. Perier (*Sem. Méd.*, May 18, 1892) and others have carried the same principle still further by the introduction of plates shaped from the fresh scapula of the rabbit, which is well adapted to the purpose, and Sljamer (*Wien. med. Wochenschr.*, 1900, No. 12) has utilized a celluloid plate embedded beneath the skin, while Roswell Park has also employed ivory and silver foil (*Trans. Amer. Surg. Assoc.*, vol. xxiii).

Results. The committee of the Clinical Society of London, to which we have already referred, collected twenty-three cases of excision of the sac, of which sixteen recovered and seven died, but a review of the many published cases leads to the conviction that the true mortality of this operation is little if any less than 50 %. Of eight operations performed at the Manchester Children's Hospital, five recovered and three died, the five recoveries all being simple meningoceles (Telford).

The statistics of Boettcher are especially valuable in this connexion, as they represent the personal observation of one surgeon on a relatively large number of cases (Armour, *Lancet*, March 7, 1908). He reports sixty-four cases of spina bifida, of which thirty-nine were submitted to operation. Of these no less than thirteen died immediately from shock, and of the remaining twenty-six cases, twelve died within a few months. Fourteen only (36 %) recovered and were cured of their tumours, these fourteen being, with one exception, meningoceles. These results are very unsatisfactory, but it is difficult to see in what way they are greatly to be improved by changes in operative technique, as the underlying causes of the deformity and of its associated hydrocephalus, from which many cases die, do not appear to be amenable to surgery, while, in cases of serious involvement of the spinal cord and nerves, it is probable that there are equally far-reaching developmental errors. We are thus almost justified in saying that, except in the case of simple meningoceles, recovery from spina bifida will remain rare, whether operation is or is not performed.[1]

[1] Armour (*loc. cit.*) has collected the statistics of many writers and expresses his conclusions as follows: 'In all cases of myelocele, in most cases of myelo-meningocele with paralytic complications, in the presence of sepsis or associated hydrocephalus, it [the operative prognosis] is extremely bad, even wellnigh hopeless. In those operated on within the first few months of life the mortality is over 35 %, whilst in those operated on when five or more years old the mortality is 4·7 %. This difference can be largely accounted for by the fact that the patients living five years or more are not bad cases, and are presumably good subjects for operation.'

CHAPTER XI

LAMINECTOMY

FROM an etymological point of view the term laminectomy is open to objection, but the more correct forms of lamnectomy and rachiotomy have never found general acceptance, while the expressions 'resection of the vertebræ' and 'resection of the vertebral arches' are cumbrous, so that the nomenclature which has now become general will be adopted throughout the following pages. Earlier writers have commonly employed the expression 'trephining the spine', but this has now been discarded and has the double disadvantage that the trephine is seldom actually used, while a very false analogy is suggested with operations upon the skull.

As with many other branches of surgery, the operative treatment of affections of the spinal cord and its membranes is of very recent development, but suggestions may be found as far back as in the writings of Paulus Æginctus and Fabricius Hildanus, while Louis (1762) was apparently the first to act upon these in a case in which he successfully removed fragments of a vertebral arch broken by a gunshot wound. The first deliberately planned operation appears, however, to have been that of Cline, who, on the suggestion of Sir Astley Cooper, operated in 1814 upon a case of 'fracture-dislocation' of the eleventh dorsal vertebra, removing two spinous processes and one arch; the spinal cord was almost torn through, and the patient died on the nineteenth day. From that time until 1889 about sixty or seventy more or less similar operations were undertaken in cases of spinal injury, the majority in the United Kingdom and in America, but the results were by no means encouraging, and no definite 'surgery of the spinal cord' could be said to exist.

In the case of pressure lesions of the cord the first efforts of surgery were naturally of later date, but in 1882 Jackson of Sheffield operated upon a case of paraplegia due to spinal caries, obtaining an amount of recovery which, if not complete, was at least very striking. Within the next two years the work of Macewen of Glasgow brought prominently into notice the surgical

treatment of this form of paraplegia, and from that date laminectomy has been constantly performed for disease as well as for injury. Sir William Gowers and Sir Victor Horsley, in their classical case (1887) of removal of an intrameningeal tumour (*Med.-Chir. Trans.*, 1888, vol. lxxi), gave the subject further impetus, and the fortunate coincidence of improvements in general surgical technique with a precise appreciation of the localization of function in the various segments of the cord has so far extended the possibilities of surgical treatment that, since 1890, laminectomy has been adopted for a large number of diseases as well as for traumatic conditions.

NEUROLOGICAL LOCALIZATION

The essential basis of all spinal surgery is a correct localization of the seat of disease, which is sufficiently simple in the case of injury and in some cases of caries, but which is less simple where we have to deal with tumours. It will therefore be convenient at the outset to consider very briefly the functions of the various spinal segments and their anatomical position in relation to the available bony landmarks of the back. In so doing, all controversial matter will be avoided as far as possible, and for fuller details reference must be made to works upon neurology.

Motor paralysis usually extends upwards as far as the muscles supplied by the affected segment of the cord, and in cases of incomplete paralysis it may be taken as a general rule that of those segments which lie below the lesion the higher are more paralysed than the lower. *Sensory defects*, on the other hand, tend to be more marked in the lowest segments, so that the upper level of *complete* loss of sensation may be a considerable distance below the level of the lesion. The dissociation of tactile and pain sense is, however, common, and it may be found that appreciation of such stimuli as the prick of a pin is lost to a much higher level than appreciation of tactile sense, while deep sensations in bone and muscle persist even below the level of complete cutaneous anæsthesia. Hence, in determining the upper level of a lesion, it is essential to ascertain the very highest level at which there is any defect of any form of sensation, and not to regard the boundary line of *full* anæsthesia as determining the segmental level of pressure. *Pain* is generally most marked in the distribution of the highest affected segment, or of nerve roots which arise above the segment and are compromised in their intravertebral course; in the case of intrameningeal tumours, the long duration and fixed position of pain are especially valuable indications of the site and nature of the lesion. The

presence or absence of *reflexes* is of comparatively little value in ascertaining the level of a lesion except in so far as it enables us to distinguish lesions of the cord from those of the cauda equina.

The localizing value of motor symptoms is greatest in the case of the brachial enlargement, and the extent of paralysis of the arm muscles can be accepted with great certainty as determining the site of the lesion in the cord. The risk of error is also lessened in the cervical region by the fact that the intravertebral course of the nerve roots is comparatively short, not greatly exceeding an inch even in the case of the first dorsal root. In the whole of the dorsal cord the motor functions give very little assistance in segmental diagnosis, as it is not easy to define which of the intercostal muscles are in action and which are not. In the lumbar enlargement the various segments become so crowded together, all lying within the vertical depth of three vertebræ, that their differentiation by motor symptoms is almost, if not quite, impossible.

Sensory symptoms—if due regard be paid to ascertaining the highest level of any defect—are of equal value with motor symptoms in the case of the cervical enlargement. In the dorsal cord they have a far greater value, and it will be upon sensory defects that we shall now principally rely. In the lumbar enlargement the difficulties due to crowding of segments are as great as in the case of motor symptoms. In every region hyperæsthesia and pain, when present, are generally due to pressure upon nerve roots rather than upon the cord itself, and they will thus locate the source of pressure as being between the medullary origin and the vertebral exit of the root concerned. Thus, anæsthesia and paralysis extending to the limits of one segment, with pain or hyperæsthesia and with or without paralysis of one or two segments above, would indicate that the cord was compressed at the level of the segment showing anæsthesia, while the higher segmental symptoms were due to involvement of the roots lying alongside the compressed cord.

In the case of the lumbar enlargement the segments occupy so short a vertical distance that their differentiation becomes very difficult, but for surgical purposes this is of comparatively little importance, as the whole area can be exposed by the removal of some three arches. We are now, however, met by the difficulty that the intravertebral course of the spinal roots is long, extending in the most extreme case from the lower border of the first lumbar vertebra to that of the third or fourth sacral, a distance of several inches. It thus becomes important to distinguish affections of the cauda equina from those of the cord itself, and especially from those of the conus medullaris, a distinction which is the less easy as, in cases where pressure is above the lower border of the first

lumbar vertebra, both may be involved. We may, however, lay down the following as general rules, admitting that they are not infallible guides:—

1. Marked asymmetry of the symptoms points to the cauda equina as their seat of origin.

2. Exaggeration of deep reflexes points to the lesion being in the cord and above the reflex arc, which in the case of the knee-jerk is the second and third lumbar, and in the case of ankle clonus and the Babinski reflex is situated in the first, second, and third sacral segments.

3. Abolition of the deep reflexes generally indicates a lesion of the nerve roots, the loss of the reflex being determined by interruption of either the afferent or the efferent fibres. In cases of extreme pressure and severe crushes, the reflexes may be abolished by damage to the reflex centre in the cord itself, but in such cases the anæsthesia and paralysis will tend to be more complete than in lesions of the cauda equina alone.

4. Where there is a clear restriction of symptoms to a limited portion of the lumbo-sacral area the lesion will almost certainly be caudal rather than medullary, as in the latter case almost all segments are involved, either together or in rapid succession.

5. Similarly, the slow progress of symptoms from segment to segment will point to a caudal lesion.

6. Pain and hyperæsthesia will here, as elsewhere, indicate an affection of the nerve roots rather than of the cord itself, and great severity or long continuance of pain point strongly to the cauda equina.

7. Where symptoms of paralysis and anæsthesia are incomplete we find that, if the cauda equina be affected, both tend to be most marked in the lowest roots, while in the case of an affection of the spinal cord paralysis usually reaches its highest level in the area of the segment attacked.

With these preliminary considerations we may proceed to indicate the functions of the various spinal segments, and, although there is still considerable difference of opinion on certain points of detail, these are now sufficiently well defined to admit of a tabulation which is enough for the purposes of the surgeon. The annexed tables and diagrams are, therefore, only approximately accurate, and are intended to express what I take to be the collective opinion of various observers, while they differ slightly from my own earlier work, which has in the last twenty years been amplified and revised by many neurologists.

PRINCIPAL MUSCLES SUPPLIED BY EACH SPINAL SEGMENT

Cervical I.	Small muscles of neck and distribution of descendens noni nerve.
Cervical II and III.	Diaphragm, sterno-mastoid, trapezius.
Cervical IV.	Diaphragm, supraspinatus, infraspinatus.
Cervical V.	Biceps, brachialis anticus, deltoid, supinator longus, supinator brevis.
Cervical VI.	Subscapularis, pronator quadratus, pronator radii teres, teres major, latissimus dorsi, pectoralis major, serratus magnus, triceps.
Cervical VII.	Long extensors of the wrist and fingers, secondary supply of many of the muscles of the sixth segment, and of flexors of the wrist and fingers.
Cervical VIII.	Long flexors of the wrist and fingers.
Dorsal I.	Intrinsic muscles of the hand.
Dorsal II to XII.	Intercostals and abdominal muscles.
Lumbar I.	Abdominal muscles.
Lumbar II.	Abdominal muscles, cremaster, psoas (?), iliacus (?), sartorius (?).
Lumbar III.	Adductors, psoas, iliacus, sartorius.
Lumbar IV.	Quadriceps femoris, glutei, obturator externus.
Lumbar V.	Hamstring muscles, glutei.
Sacral I.	Muscles of calf, gluteus maximus.
Sacral II.	Extensors and flexors of the ankle and toes, peronei, intrinsic muscles of the foot.
Sacral III.	Perineal muscles, intrinsic muscles of the foot.
Sacral IV and V.	Bladder and rectum.

This table is to be regarded as a compilation from the work of various writers, and not as expressing in all cases the personal observations of the author. As far as possible all doubtful cases are entirely omitted, and those muscles only are named whose condition may fairly be relied upon for purposes of diagnosis. In the case of the lower lumbar and upper sacral segments especially there is still much uncertainty.

THE SENSORY DISTRIBUTION OF THE SPINAL NERVE ROOTS

This has been more fully studied than have the motor connexions, and the diagrams published by various writers[1] present considerable differences, but I am still of opinion that the figures which I published from 1887 to 1896 represent with sufficient accuracy the data for regional diagnosis. These are now reproduced with some minor modifications, embodying later work or the researches of others, and they are drawn asymmetrically so as to show as far as is possible in diagrams (see Plates I and II) the principal variations and the more marked differences in the opinions of various observers.

SKELETAL LOCALIZATION

The localization of the lesion *in relation to the spinal cord* having been determined, it is also necessary to ascertain the level at which it is situated *in relation to the bony points* which can be felt, as the various medullary segments are not situated opposite the bodies of the vertebræ whose names they bear, and still less do they correspond to the spinous processes of those vertebræ. Thus, the brachial enlargement of the cord lies approximately opposite to the third, fourth, fifth, sixth, and seventh cervical spines, the lumbar segments opposite the eleventh and twelfth dorsal, and the sacral segments opposite the spinous process of the first lumbar vertebra. In somewhat fuller detail it may be calculated that, in the region of the neck, each segment lies higher than the tip of the correspondingly named spinous process by about one segment, so that, for instance, the fifth cervical nerve roots arise from the cord at the level of the spine of the fourth vertebra. In the dorsal region there is considerable variation, but approximately each medullary segment lies under the spinous process of the second, or, lower down, of the third vertebra above that which bears the same name and number, until we find the twelfth dorsal segment under the ninth spinous process, after which the remainder of the cord is so short that the termination of the conus medullaris is situated immediately beneath the gap between the first and second lumbar spines, the eleventh dorsal spinous process lying over

[1] Starr, *American Journal of the Medical Sciences*, July, 1892; *Brain*, 1894, p. 431. Head, *Brain*, 1893, p. 1. Mackenzie, *Medical Chronicle*, August, 1892. Kocher, *Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, Jena, 1896. Thorburn, *Surgery of the Spinal Cord*, London, 1889; *Brain*, 1893, p. 355; *Medical Annual*, 1896, p. 97; *Brain*, 1903, p. 120. Seiffer, *Das spinale Sensibilitätsschema*, Berlin, 1901.

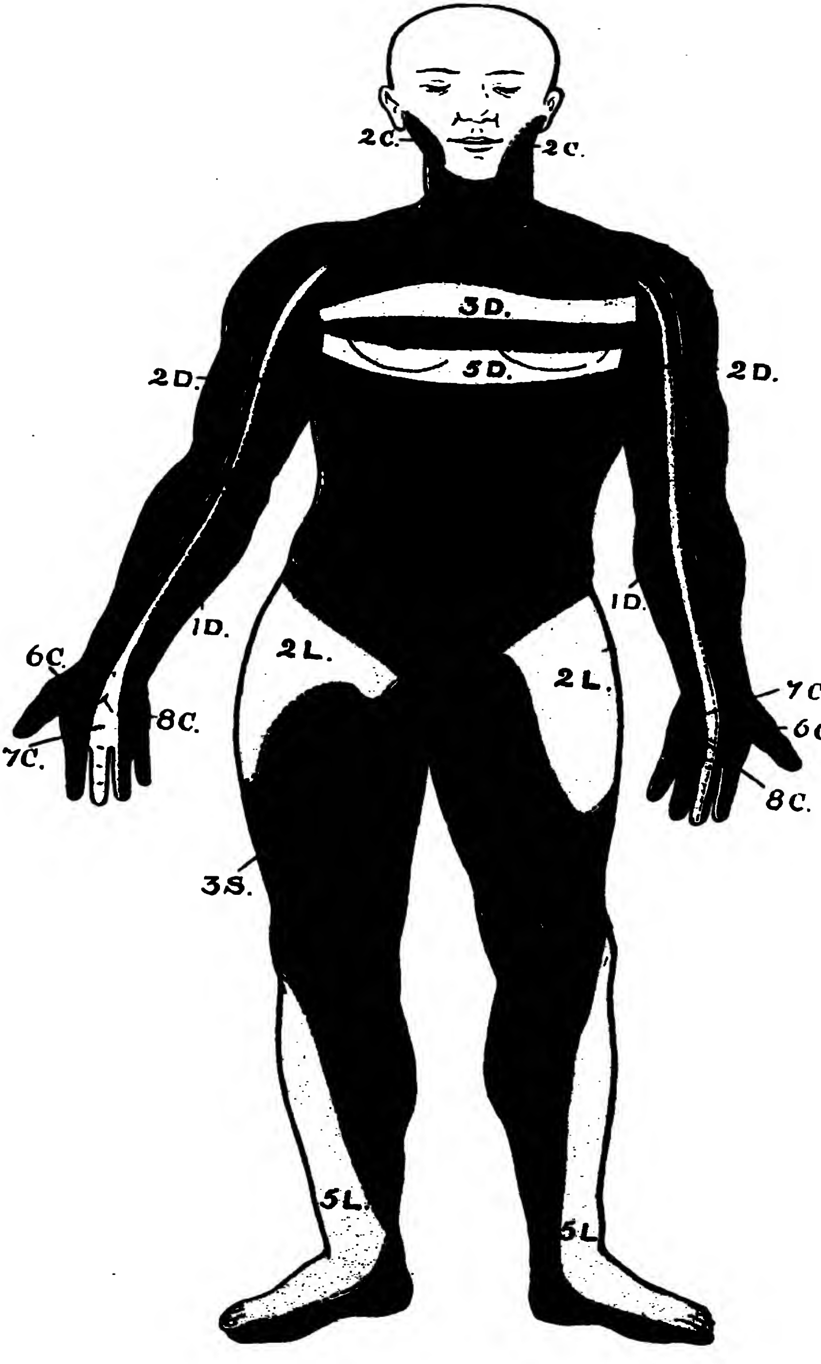


Plate 1.—Diagrammatic representation of the Sensory distribution of spinal segments (anterior view).

the third and fourth lumbar segments, and the twelfth spine over the sacral region of the cord. The whole of these relations have been very carefully worked out by Reid (*Journ. of Anat. and Phys.*, 1899, vol. xxiii, p. 341), who has also illustrated in diagrammatic form the extent of variation usually met with (see Fig. 141).

Lastly, it must be pointed out that, even in regard to 'surface anatomy', it is by no means always easy to define and count the spinous processes, and that, in stout people especially, it may be almost impossible to be quite certain as to their distinction. It is generally wise, in all difficult cases, to count both from above and from below, and to obtain the agreement of at least two observers. In so doing, the necessary calculations may be made from the axis, the seventh cervical spine, the last dorsal or second sacral spine, or from the lower end of the sacrum. The seventh cervical spinous process is by no means always so prominent as the name

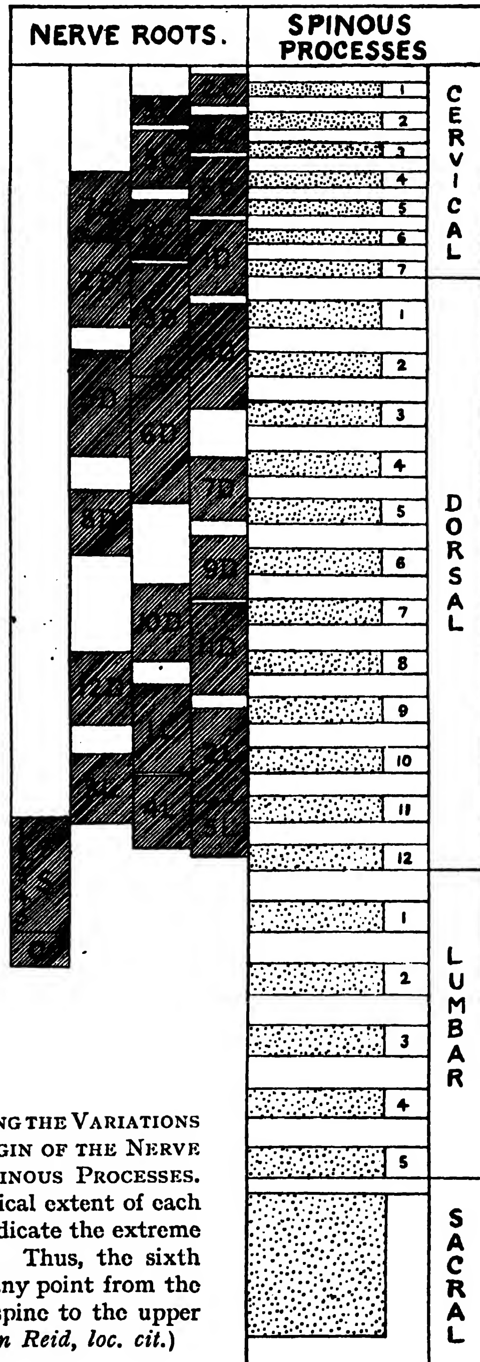


FIG. 141. A DIAGRAM INDICATING THE VARIATIONS IN THE RELATIONSHIP OF THE ORIGIN OF THE NERVE ROOTS TO THE APICES OF THE SPINOUS PROCESSES. The dotted areas indicate the vertical extent of each process; the areas shaded in lines indicate the extreme variations of origin of each root. Thus, the sixth dorsal root may leave the cord at any point from the lower border of the second dorsal spine to the upper border of the fifth. (*Modified from Reid, loc. cit.*)

'vertebra prominens' implies, and it and the first dorsal spine are liable to be very close together and to be regarded as one process only. The last rib indicates the position of the twelfth dorsal vertebra, but may be itself difficult to identify, while it is impossible to trace it with precision to the vertebra and its spine, and we have to rely upon a somewhat doubtful mental picture of the relation of these structures. The posterior inferior spines of the ilia can almost always be defined, and these appear to bear a constant relation to the second sacral spinous process, which lies between them, so that it is not difficult to count upwards to the desired vertebra. In practice, the writer generally works upwards from the twelfth dorsal and downwards from the seventh cervical, and if the results do not agree, or if the region investigated be low down in the spine, the second sacral is used as an alternative landmark. In the neck the spine of the axis can be felt, but those of the third, fourth, and fifth cervical vertebrae cannot as a rule be defined, although the sixth is often distinctly prominent. It may also be occasionally convenient to remember that the hyoid bone is opposite the body of the fourth cervical vertebra; the cricoid cartilage is opposite that of the sixth; the top of the sternum is opposite the lower border of the body of the second dorsal; the lower angles of the scapulæ, when the arms are by the sides, correspond very roughly to the spinous process of the seventh dorsal or body of the eighth; and the umbilicus is opposite the disk between the third and fourth lumbar vertebræ or the tip of the third lumbar spinous process, the tops of the iliac crests being lower by the depth of one vertebra.

Lastly, in many cases, a skiagram will be required as a preliminary to operation, and it may be found useful in obtaining this to place a metal button or coin over the spine of a vertebra, such as the twelfth dorsal, whose position has been previously estimated; the picture will then confirm or correct the landmark.

INDICATIONS FOR OPERATION

The operation of laminectomy has been adopted in various conditions, some of which necessitate special procedures, but in all of which the greater part of the technique is identical, so that the indications may first be considered collectively under the following headings:—

(i) Injuries of the spinal cord, including pressure due to bony displacement, hæmorrhage, foreign bodies, callus and cicatrices, and section or tearing of the cord and its membranes.

(ii) Injuries of the cauda equina.

(iii) The effects of tuberculous and other forms of caries of the vertebræ.

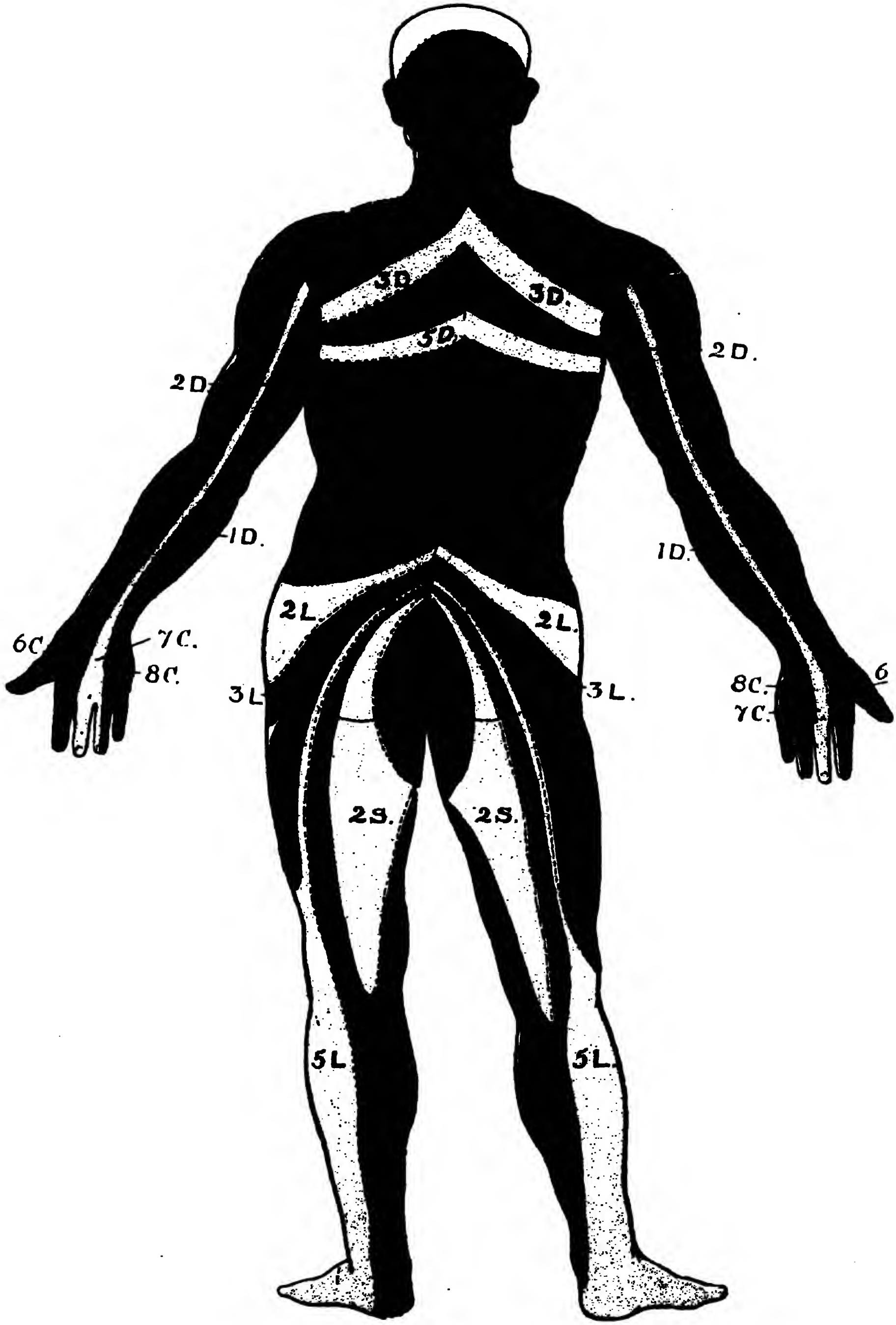


Plate 2.—Diagrammatic representation of the Sensory distribution of spinal segments (posterior view).

(iv) Tumours, including cysts, of the spine, meninges, nerve roots or cord, spina bifida occulta, and the cicatrices of old spina bifida.

(v) Inflammatory affections of the meninges.

(vi) Intractable neuralgia of the spinal nerves.

Injuries of the spinal cord. The injuries for which operation has been suggested or undertaken vary considerably in their nature and include the most diverse conditions.

1. *Fractures of the spinous processes alone* are very rare, there being only two cases recorded among Ashhurst's 394 collected injuries to the spine, and seven among Gurlt's 270 collected fractures. Personally, I have met with but two examples and I have found records of twelve, in only three of which the cord was injured, so that operation cannot often be required for this condition. When it does occur the removal of the fractured spinous process presents no difficulties and is not, strictly speaking, laminectomy, but it hardly appears to be called for in uncomplicated cases. If, however, the fragment be depressed or wedged between adjacent laminæ so as to give rise to fixation of the spine or to much pain, and especially if it be associated with any evidence of injury to the contents of the vertebral canal, its removal is certainly indicated, and, in the case of injury to the cord, it will generally be wise also to remove one or even two adjacent laminæ, so as to allow a full exposure of the damaged region and to ensure the complete removal of any fragments of bone.

2. *Fractures of the laminæ alone* are more important, although equally rare, but the wisdom of removing detached laminæ can hardly be doubted, as, even if they are not primarily associated with pressure symptoms, there is a considerable risk of their becoming depressed at a later date. In a few cases this operation has been performed, one of the most satisfactory being that of Schede, in which the sixth dorsal arch was detached and driven in upon the theca, causing complete paralysis and anæsthesia with vesical and rectal paralysis: the arch was removed sixteen hours after the injury and complete recovery ensued. In several other cases the same procedure has been adopted, although it has not been invariably successful.

3. *Fractures and dislocations of the bodies of the vertebræ* may be considered together as 'fracture-dislocations', the technical distinction between the two conditions rarely being of practical importance. In the case of unilateral dislocations of the cervical vertebræ the cord is frequently either intact or but very slightly injured, and reduction of the deformity is often practicable. Under such circumstances a cutting operation is not required, but, should there be symptoms pointing to any injury of the spinal cord, the advisability or otherwise of performing

laminectomy will be decided by the considerations which apply to other fractures and luxations.

In the common 'fracture-dislocation' the upper vertebra is displaced forwards in such an overwhelming preponderance of cases that all other forms may be neglected, and the lower vertebra is usually broken obliquely as in the annexed figures. Under such circumstances the spinal cord and its nerve roots are compressed between the posterior part of the body of the lower vertebra and the arch of the upper one, the injury being possibly increased by traction upon the cord during the extreme flexion to which the fracture is generally due. In many such cases the displaced bones remain displaced, and the theca and its contents, if not torn quite across, are subject to continuous compression, as in the specimen shown in Fig. 142. In other cases there follows immediately after the injury a considerable amount of recoil, and the pressure, having been momentarily inflicted, is again relieved, the vertebral canal being left quite patent as in Fig. 145. In the experience of the writer, about two-thirds of all pathological specimens show such recoil, so that there is no permanent pressure upon the cord, while in only about one-third is continued compression demonstrable at an operation or a post-mortem examination.

FIG. 142. FRACTURE-DISLOCATION OF THE CERVICAL SPINE, SHOWING PERSISTENT DISPLACEMENT. The cord and theca were torn across completely.

More rarely the damage done to the contents of the vertebral canal may result, not from kyphosis and crushing of the cord between the lamina of one vertebra and the body of the next, but from impaction of a small detached fragment of bone, from the forcing backwards of an intervertebral cartilage, which forms a projecting shelf pressing upon the cord, or from hæmorrhage into the theca or perithecal space. Traumatic hæmorrhages into the cord itself are probably always the result of one

or other of the forms of injury already enumerated, although in many cases of hæmatomyelia the displacement is so slight and transient that it cannot be readily recognized as a dislocation, and is conveniently described as a 'diastasis'.

The injury inflicted upon the cord in connexion with these various conditions may consist of mere contusion with intramedullary hæmorrhage (hæmatomyelia), or contusion with continued compression, or of complete rupture; and in each case it will usually be followed by softening or myelitis, which extends for some distance beyond the original focus of injury, and by ascending and descending degenerations similar to those met with in other forms of transverse myelitis.

FIG. 143. FRACTURE-DISLOCATION AT THE DORSO-LUMBAR JUNCTION. The damaged theca and its contents are fully released from pressure by recoil.

The possible variations in the exact nature of the injury being thus recognized, it will be obvious that somewhat different results may be anticipated from laminectomy under the various conditions. Where the cord has been crushed and immediately released by recoil, there being no further bony pressure, the only object of operation will be to remove effused blood or to suture a torn cord or theca. Where, on the other hand, the displacement is not followed by recoil, the removal of the arch of the upper displaced vertebra, or of the projecting angle of the lower vertebra, will relieve the compression, as well as allow of the escape of blood or the use of sutures. These are the two conditions met with in the great majority of cases, and neither of them offers much prospect of successful treatment.

Injury by isolated fragments of bone is exceedingly rare, and I am not aware of any clearly reported examples in which it has been detected

at and successfully treated by an operation. In injury by the backward extension of an intervertebral disk, as in that by isolated fragments of bone, the conditions more nearly resemble those of pressure by tumours, and there is some hope of a satisfactory result; but, again, such a condition is very rare and not likely to be recognized. In one of the writer's early cases the true state of affairs was discovered only after death on the sixteenth day after operation.

Extra-medullary hæmorrhage sufficient in amount seriously to compromise the cord, and unaccompanied by bony displacement, is also rare. The bleeding in these cases is generally derived from the veins of the spine itself and leads to the formation at the seat of injury of a clot which encircles and compresses the theca. In the case of Church and Eisendrath (*Amer. Journ. of Med. Sci.*, April, 1892) a fracture-dislocation of the tenth dorsal vertebra was associated with paraplegia; laminectomy disclosed a firm extra-dural clot which was removed, and recovery was almost complete. Wagner also records a case of bullet wound at the level of the ninth dorsal vertebra in which, three months after the injury, a firm fibrous cicatrix, apparently due to a clot, was removed with complete cure of the pre-existing paraplegia. Equally rare is the condition which may be described as 'gravitating hæmorrhage', met with by Bennett, Liddell, myself, and others, and probably due to hæmorrhage inside the dura mater, with a collection of blood filling the theca from below upwards. In a suspected case—that is, in a case of spinal injury followed by steadily ascending paralysis—the diagnosis could probably be made by meningeal paracentesis, and it is conceivable that such paracentesis might relieve the symptoms and lead to recovery; but, if it failed to do so, laminectomy and drainage of the theca holds out a hopeful prospect, although we have not met with an example in actual practice.

Although an attempt has thus been made to distinguish the various forms of injury which may be met with, and the prospects of successful operation in each, it is, however, very rarely that such distinctions can be made in actual practice. In the great majority of cases the diagnosis will be limited to the recognition of a fracture-dislocation with more or less complete paraplegia, and operation alone will determine the precise nature of the lesion. Under such circumstances the surgeon will realize that he has to deal with one of the three following conditions:—

(*a*) Displacement of a vertebra with crushing of the cord and immediate recoil, in which there is very little prospect of benefit from operation, as there is no necessity to remove pressure.

(*b*) Displacement *without* recoil, in which pressure can certainly be relieved, but in which the fatal analogy of those cases where the cord

has been at once released by natural recoil leaves us little to hope from relief by art.

(c) Rare cases of injury by fragments of bone or cartilage or by hæmorrhage, in some of which beneficial results have certainly followed operation.

Taking this view, we cannot hope to find any very satisfactory results from laminectomy for recent injuries. Personally, I have operated only upon five cases of recent fracture-dislocation with crushing of the cord, and in none of these could I satisfy myself that any real good had been done. I also collected, some years ago, over 200 published cases in which the results were equally unsatisfactory. Life may of course be preserved in many cases in which the injury is not too high up or too complete, and even a considerable amount of recovery of function may occasionally occur, but such results are met with equally among cases not operated upon, and it is not altogether uncommon to meet with a remarkable amount of spontaneous recovery or a remarkable prolongation of life among well-nursed spinal injuries.[1] In regard to published records, it is also important to remember that in many cases of hæmatomyelia a large amount of recovery may ensue, even where paraplegia appears at first to be complete, and such recoveries cannot justly be assigned to an operation which would tend to increase rather than to decrease the danger to life.

We may, then, conclude by laying down certain definite propositions:

(i) In the great majority of cases of fracture-dislocation with injury to the spinal cord, laminectomy is useless.

(ii) In a very few, operation may reveal a hæmorrhage, an impacted spicule of bone, or other removable source of pressure or irritation.

(iii) Operation must therefore never be held out as offering any but the smallest hope of success, but, the situation having been fully explained to the patient or friends, it may, if desired, be undertaken as a 'last chance'.

(iv) If undertaken it should be complete, in the sense of including a search for, and removal of, all possible sources of pressure, including the pressure backwards of the body of the lower of the affected vertebræ (see *infra*).

(v) As regards the period at which it is to be undertaken, there is a general consensus of opinion that acute shock and hyperpyrexia are contra-indications, but, apart from these considerations, many surgeons

[1] I would protest strongly against the tendency to abandon hope in all cases and to neglect those details of nursing and general treatment which ought to be carried out with the same determination to strive for success as in all other diseases.

urge operation at the earliest possible moment as being best calculated to save the spinal cord so far as possible. Lloyd (*Philadelphia Med. Journ.*, February 8, 1902) argues that we should wait until shock has passed away and events have shown that improvement in symptoms will not ensue, but that operation should not be delayed if symptoms are extending or if early improvement is arrested. Horsley (*Clinical Journal*, January 13, 1897) says, 'If the lesion is acute and in the cervical region, then certainly wait. As regards the dorsal region, it would be better to wait a little. As regards the lumbar region, I do not think you want to wait to operate.' Personally, having had no success in operation upon acute cases, and having seen many cases show a great amount of spontaneous improvement, I should prefer always to wait until satisfied that the cord was not destroyed. I doubt if we shall ever get beyond the position adopted by Lloyd, that 'it is the compression, and only the compression without injury to the cord, that can be benefited, and this may be taken as an axiom in the surgery of the spine'. Taking this view, it appears reasonable to wait until the case presents a stage of uncomplicated compression, unless, as in rare hæmorrhages, the latter be increasing in intensity.

The somewhat pessimistic view which I have thus ventured to express has remained unaltered after many years, and was originally arrived at only as a result of much disappointment. Nor can I regard the more enthusiastic opinions which are often met with as being based upon satisfactory evidence. The case in favour of operation can hardly be put more strongly than in the following quotation from Armour (*Lancet*, March 14, 1908): 'In respect to the question of operation in those cases, surgeons have been divided into three classes: those who advocate operation in every case of injury in which cord symptoms are present; those who advise operation in selected cases; and those who abstain completely from operation. To those who would operate upon selected cases I would say, as Walton does, "Surely, instead of selecting the occasional case for operation, we should rather select the occasional case in which operation is contra-indicated by profound shock, high and rising temperature, and the obvious onset of dissolution." To those who abstain from operation completely I would put this question: May we not by operation often save a life or rescue a patient from a helpless condition of a most disabling character?' I fear, however, that the answer to the question will be that we cannot *often*, but may *rarely*, save such a patient, and the decision is made greatly more difficult by the slight alteration. At the best it is hardly possible to go further than to admit, with Horsley (*Brit. Med. Journ.*, December 6, 1890), that 'trephining of the spine for injury is an operation of very slight danger

intended to meet an almost hopeless condition, and the chance of its doing any good, although also very slight, is sufficient to render it a correct practice.'

4. *Wounds of the spinal cord*, such as are inflicted by sharp instruments entering between the laminæ or otherwise, will occasionally, but rarely, be met with. The history of such cases where no operation has been adopted throws some light upon the whole question of spinal surgery, and I have therefore analysed a number of published examples. In forty cases of stabs or cuts by sword, bayonet, knife, or chisel the meninges were wounded; of these cases fifteen died, and of the deaths nine were due to septic infection. So far, therefore, as mortality is concerned, the dangers are not great, apart from sepsis, which would be diminished by full exposure and cleansing of the wound. The escape of cerebro-spinal fluid is a common symptom, but never a very serious one. As regards the recovery of function of the cord the results are, however, bad. In only thirty-four of the forty cases was the cord injured, the remaining six being limited to the meninges or the cauda equina. Of the thirty-four cases in which the cord was involved, twenty-one survived, and of these three appear to have recovered entirely, sixteen presented permanent paralysis or anæsthesia or both, and two were said to be improving when last seen. In the great majority of cases the wound is followed by paraplegia, which shortly passes away, leaving a crossed paralysis and anæsthesia of the Brown-Séquard type; that is to say, one half only of the cord has been cut and the first effects of hæmorrhage and pressure rapidly pass away, but the actual section is not repaired.

These results indicate very clearly the improbability of restoration of function in those parts of the cord which have been actually cut, and they are thus in accord with most physiological observations. They suggest that suture of the divided or partially divided cord may be of service, but is not likely to be. With such evidence we may say that, granting it is wise to explore and drain an accidental wound of the spinal cord or its meninges, we may also proceed to suture with the most accurate apposition any cut surfaces, but that the prospects of recovery are by no means hopeful. Suture has, however, been practised in at least three cases in which partial recovery has ensued.[1] Harte and Stewart (*Trans. Amer. Surg. Assoc.*, 1902, p. 28) record a case of bullet wound at the level of the seventh dorsal vertebra: three hours after injury the cord was found severed, its ends being $\frac{3}{4}$ inch apart, with the bullet and some fragments of bone interposed:

[1] Duncan (*Edin. Med. Journ.*, March, 1889) appears to have been the first to suture the torn dura mater over a crushed segment of cord, but no benefit resulted.

three chromic gut sutures were passed through the cord, but the torn theca could not be approximated: at the end of a year the patient could move from her bed to a chair and stand with support. Estes stated in the discussion of this case by the American Surgical Association that he had exsected $\frac{3}{4}$ inch of the cord and sutured the ends, obtaining an amount of recovery sufficient to allow the patient to stand. Fowler (*Annals of Surgery*, 1905, p. 507) describes a gunshot wound at the level of the eleventh dorsal vertebra, on which he operated on the tenth day, the patient showing some slight subsequent improvement. It would thus appear that the fully reported case of Harte and Stewart was followed by a considerable amount of recovery, but in Fowler's case the recovery was not obviously the result of operation, while Estes' report is by no means complete.

5. *Gunshot wounds* of the cord due to the high velocity bullets used in modern warfare were not uncommon in the war in South Africa. Of these I have no personal experience, but there appears to be little doubt that the injury inflicted is generally irreparable and that, as with so many other injuries due to modern firearms, surgical interference is more likely to do harm than good (Makins, *Surgical Experiences in South Africa*, 1899-1900). When, however, the bullet is lodged in an accessible position it is clearly advisable to remove it, and in a very considerable number of cases, as in those quoted in the last paragraph, the removal of revolver and other bullets has given most satisfactory results. Unfortunately in the majority of cases it will be deeply buried and will have at once irreparably damaged the spinal cord.

6. *The late results of injury to the cord.* The above remarks apply more particularly to laminectomy in recent injuries of the cord, but there remain to be considered those cases in which the injury has been survived but has left more or less complete paralysis, or in which recovery is followed by the later development of compression paraplegia.

The prospects of benefit from operation will here depend upon the nature of the residual lesion. If paralysis and anæsthesia be complete and permanent, and especially if they be associated with abolition of the deep and visceral reflexes, the probabilities are that the cord has been completely crushed and that operation will reveal a mere fibrous cicatrix lying within and more or less completely united to a theca which may, or may not, be itself compressed. Such cases are quite hopeless. On the other hand, less severe symptoms, and especially symptoms of late development or of gradual evolution, are often due to compression by callus, pachymeningitis, or it may be unabsorbed blood-clot, and cases of this class are susceptible of great improvement; they again fall into the class of compression injuries and not into the hopeless class

in which the cord has been destroyed. Laminectomy may therefore be regarded as indicated in all cases of old injury with persistent symptoms, except perhaps in two groups which occupy the extreme ends of the scale, *viz.* (1) those in which the symptoms point clearly to complete destruction of the cord and (2) those in which the residual symptoms are stationary and so slight as not to give rise to practical inconvenience. In doubtful cases exploration is probably quite justifiable. In eleven operations undertaken for old injuries of this type I have five times found the cord converted into a fibrous cicatrix and have obtained no improvement, but the remaining six all showed some amount of recovery of function, three presenting very great improvement although the results of descending degeneration were permanent.

Injuries of the cauda equina. The nerve roots which constitute the cauda equina are more closely allied in their physiological functions to peripheral nerves than to the more vulnerable spinal cord, and Kahler, Chipault, and others have shown that in animals these may be cut and sutured with complete recovery of function, while in man Tuffier sutured the two first lumbar roots, which had been divided by a bullet wound, and obtained perfect recovery. There is thus much more reason for hope after crushing and other injuries of these roots than after injuries of the medulla itself, and experience fully confirms this view. Many cases of fracture-dislocation below the level of the first lumbar vertebra, or even at that of the dorso-lumbar junction, are followed by complete return of function even after paraplegia has lasted for weeks or months, and I may almost go so far as to say that such cases will generally recover unless there be distinct separation of the ends of the nerves by distance, or by the interposition of fragments of bone, foreign bodies, cicatrices, or callus. Should spontaneous recovery not ensue, laminectomy has here a definite objective, and nerve suture or the removal of pressure is certainly called for. It is also important to note that continued pressure, as apart from crushing followed by recoil, is far more common in this region than in the neck. It would therefore appear that in injuries of the cauda equina laminectomy is likely to prove of great value, but as spontaneous recovery may ensue it will not always be required.

The principal question, therefore, which arises in such cases will be that of the amount of delay which may be justified by the hope of recovery without operation. Speaking quite generally I have usually taken a period of six weeks as a somewhat arbitrary limit, and have operated after this interval if spontaneous recovery is not obviously in progress. In cases with marked deformity, as well as in those in which a skiagram shows great displacement, there is, however, a strong probability of

apposition or close juxtaposition of the anterior and posterior bony walls of the vertebral canal, and in such it is advisable to operate at once, as the roots are now almost certain to be prevented by the interposition of bone from effecting their own repair. Severe vesical troubles will also indicate the necessity for early operation, although unfortunately in many injuries about the dorso-lumbar junction the vesical paralysis is due to an injury of the conus medullaris as well as of the cauda equina, so that the prognosis after operation becomes much less satisfactory. Probably the best general rule will be to operate at once in cases with very marked displacement, but in all other cases to await developments, operating early if the symptoms are severe and show no tendency to improve, but delaying in all cases in which the progress continues to be satisfactory.

Paraplegia of spinal caries. Spinal caries, associated with affections of the cord or nerve roots, is generally due to tuberculosis, but may result from syphilis, actinomycosis, and certain other conditions such as erosion by aneurysms. Of these, the last are quite beyond relief by laminectomy, while in syphilis and actinomycosis it will rarely be necessary or useful to operate for the relief of pressure, so that practically tuberculosis only claims attention in this section.

In a comparatively small number of cases tuberculous disease is limited to the spinous processes, laminæ, or articular processes of the vertebræ, and is producing paraplegia by direct pressure upon the spinal cord. In such the operation of laminectomy both removes the disease and relieves the complication, and its value cannot be questioned. We here simply follow the general rules which govern the treatment of tuberculous disease in readily accessible bones.

More important is the question of operation in paraplegia due to caries of the bodies of the vertebræ, with or without kyphosis. In such cases the cord is subject to pressure, and the paraplegia is of more or less gradual onset, but it is very rare indeed for the pressure to be due to bone; in other words, it does not generally arise from kyphosis with squeezing of the cord between the body of one vertebra and the arch of another, or from a secondary fracture-dislocation of the diseased vertebræ, and the bony canal of the spine is seldom much narrowed, although some narrowing may be present and may intensify the pressure.

The usual condition is one of pressure by tuberculous tissue within the vertebral canal, and such may exist as granulation-tissue, as caseous débris, as an actual abscess, or, in older cases, as a firm cicatrix of leathery consistence. All the usual modifications of 'cold abscesses' are also here met with, and fragments of necrosed bone may be present in the caseous mass. The cord itself plays a very passive part: it is pale

and compressed, and degenerative changes ensue more or less quickly and may be associated with the usual 'system-degenerations' of compression myelitis. In such cases laminectomy removes the source of pressure, and the cord may, and often does, recover, the results being similar to those which follow enucleation of tumours of the meninges. Operation thus offers hopeful prospects as regards recovery of function, but it must include as complete a removal as possible of all tuberculous material outside the theca both anteriorly and posteriorly, while the theca itself should not be opened, as it is important that infection should not spread to its interior.

The two great difficulties in deciding whether to perform a laminectomy in paraplegia due to tuberculosis are, however, that some cases are so hopelessly progressive that operation is useless and recurrence almost certain, while in many others the probabilities of recovery are very good even if no operation be adopted.

On the one hand, it is seldom justifiable to operate when the general condition is very bad, when active tubercle is present in other regions, such as the lungs, or when there is evidence of marked activity of the disease in the form of hectic temperature or rapidly increasing kyphosis. In such active cases the wiser course is to wait and hope that improvement may render laminectomy a reasonably safe proceeding. It is also wise to ascertain before removing the laminæ that a sufficient amount of bone remains in the vertebral bodies to ensure the continuity of the spine, and, apart from symptoms, a skiagram may here give much information. With these reservations I may, however, say broadly that I am not often deterred from operating by the severity of the condition.

On the other hand, it must not be forgotten that the prognosis of paraplegia due to caries is exceedingly good if the patient be kept completely recumbent for a sufficiently long time, and the tediousness of such treatment need hardly be considered, as even after operation a long interval will be required for complete bony repair. It is, therefore, advisable in the great majority of cases to keep the patient absolutely at rest on the back for at least six months before resorting to operation. If, however, the symptoms be increasing steadily, and especially if they do so rapidly, it is probably useless to continue expectant treatment, and operation should be advised. In cases which become quite stationary after about six months there is also little prospect of a satisfactory result, especially if there be indications of descending degeneration, and in such operation should again be adopted. Cases which continue to improve should be left to nature, and a very large number will make a good recovery. Cases with marked 'trophic' or

vesical symptoms are uncommon, but such symptoms appear to call for earlier operation.

The adoption of these rules will be found to limit very greatly the field of operation in paraplegia due to caries, and the results obtained are by no means good (*vide infra*). Early and frequent operation certainly yields a much larger proportion of satisfactory results, but it cannot be claimed that such results would not have ensued had more conservative methods been adopted.

Tumours. *Tumours of the vertebræ* are almost invariably malignant, and include primary sarcoma and myeloma and secondary carcinoma, sarcoma, and lympho-sarcoma. In such cases laminectomy is quite useless, and, where the diagnosis is established, it should not be adopted, although it is perfectly justifiable as an exploratory operation in doubtful cases. The coexistence of marked kyphosis with the general symptoms of pressure upon the cord will, however, usually determine the diagnosis, as will also the presence of malignant tumours in other regions. Benign tumours of the vertebræ, such as osteoma, chondroma, and myxoma, very rarely indeed grow inwards so as to press upon the spinal cord, but they may be met with and certainly call for operation. In one such case Hahn (*Neurolog. Centralblatt*, 1902, p. 621) obtained a good recovery.

Tumours growing within the substance of the spinal cord (intramedullary tumours) include tubercle and glioma, which are often multiple, and, far less commonly, sarcoma in various forms, gummata, neuroma, and other rare types. These growths are distinctly less common than meningeal tumours, and are not susceptible of removal, as in those cases in which operation has been attempted the injury done to the spinal cord has proved irreparable. Abbé (*Journ. of Nervous and Mental Disease*, 1902, p. 281) successfully excised an intramedullary sarcoma, but obtained little or no functional improvement.

On the other hand, *tumours of the meninges* yield the best results, and should unquestionably be removed as soon as they are diagnosed. Such tumours may be extra-dural or intradural, the latter being somewhat more common. The extra-dural forms include sarcoma and its modified varieties, as well as fibroma, lipoma, myxoma, lymphangioma, and hydatid cysts, and they may arise from the dura mater or the perithecal tissue or may penetrate to the vertebral canal through the foramina, in which case they are of course not truly meningeal tumours. The intradural tumours originate on the inner side of the dura mater or in the arachnoid or pia mater, and include sarcoma, fibroma, psammoma, myxoma, lipoma, endothelioma, fibro-sarcoma, fibro-myxoma, hæmangioma, lymphangioma, and (rarely) tubercle, gumma, and hydatid cysts or cysticercus. Neuroma and neurofibroma also grow from the nerve roots within the verte-

bral canal. Nearly all these growths are encapsuled and their enucleation is seldom difficult, while they do not appear to present any great tendency to recurrence. More than one-half have been described as sarcoma, but Harte suggests that it is probable that many of them have consisted of granulation-tissue, as sarcoma in other regions does not present this slight tendency to recur. If not removed they are necessarily fatal, if not to life, at least to the functions of the cord. After removal brilliant results are obtainable.

In all *doubtful cases* an exploratory operation appears fully justifiable. If the tumour be removable the gain is great; if it be malignant or irremovable no harm is done, and life may be considerably prolonged or death rendered much easier even in malignant growths of the bodies of the vertebræ, portions of which can be excised.

Syringo-myelia has occasionally been operated upon, as by Abbé and others, but the results are not encouraging and I should hesitate to interfere in cases of this class; if, however, by an error in diagnosis a case of supposed tumour prove to be one of syringo-myelia, the latter may be tapped through a fine needle, and in some cases temporary benefit has ensued.

In *spina bifida occulta* we have in effect a non-malignant tumour of highly complex structure pressing upon the spinal cord, or more commonly upon the cauda equina. Here operation is certainly indicated and here also the results are very gratifying.

In cases of cured spina bifida the cauda equina is also often pressed upon by cicatricial tissue, and the removal of this tissue may be followed by recovery which would not otherwise have occurred, as in a case recorded by my late colleague, Professor Thomas Jones.

Inflammatory affections of the meninges. Under the title of 'Chronic Spinal Meningitis' Horsley has recently (*Brit. Med. Journ.*, Feb. 27, 1909) described a number of cases in which he has operated. The true nature of many of these is still obscure, and doubtless they are by no means all of the same type, but they all appear to result from meningeal infection. The general symptoms resemble those of a tumour of the cord, but pain is less definitely localized and there are often widely spread hyperæsthetic areas: anæsthesia is incomplete and without dissociation: paralysis comes on as a widely spread weakness, often unilateral: there are no vaso-motor symptoms: the patients are almost always adults, and the upper level of anæsthesia is usually mid-dorsal; kyphosis is often present. Some of the cases appear to be due to syphilis, and several to recent gonorrhœa, while others are assigned to influenza.

Operating on twenty-one cases of this class, many of which had originally been regarded as due to tumour, Horsley found, as a rule,

excess of cerebro-spinal fluid, thickening of the arachnoid, 'matting of nerve roots,' and compression of the cord with consequent anæmia. The operation consisted in free incision of the distended theca with irrigation by strong solutions of mercuric chloride, such as $\frac{1}{2000}$, or even $\frac{1}{500}$. The wound in the theca is left open, and it is suggested that the good results obtained are analogous to those produced by laparotomy in tuberculous peritonitis.

Spiller (*Amer. Journ. of Med. Sci.*, Jan., 1909) described a similar condition as 'circumscribed serous spinal meningitis', and records a case cured by operation.

It appears probable that now that attention has been called to this condition its presence may in the future be more clearly recognized, and that its existence explains some of the cases in which a tumour has been diagnosed and not found. The writer has operated upon at least one case in which careful exploration for a tumour of the cauda equina, of which the symptoms were regarded as unequivocal, revealed no growth, but in which the theca presented distinct thickening and contained much fluid, while complete recovery ensued.

It is also important to note that, on the one hand, localized types of meningitis may, as Horsley suggests, readily give rise to subsequent acute myelitis, while the work of Orr and Rows has clearly shown how infections may reach the spinal canal along nerve roots and may thus set up local inflammatory processes.

While therefore it is still too early to define the limits of surgery in obscure cases of infective meningitis or of myelitis, there is at least some prospect that a more ready resort to laminectomy and evacuation or irrigation may arrest or cure certain of these.

Neuralgia. Abbé (*Medical Record*, July 26, 1890) operated in two cases of intractable brachial neuralgia, excising the posterior roots and ganglia of the affected nerves, the result being that one case was somewhat improved, and the other not benefited. Similar and more satisfactory cases have also been recorded by Bennett (*Brit. Med. Journ.*, 1889, vol. i, p. 945), Horsley (*Brit. Med. Journ.*, December 6, 1890), Chipault (*loc. cit.*), and others, but they are by no means common, and the operation is not one which will frequently be required. It is advisable to remove only the posterior roots and their ganglia, leaving the motor roots intact, but at the time of operation the latter may be of great value, as their stimulation by an electric current will indicate that the proper roots are being attacked. In several recorded cases the neuralgia has been cured by this method, but in others it has failed to relieve, and at least two deaths have occurred. Having regard, however, to the comparative safety of laminectomy *per se* (*vide infra*), it would appear that

a properly performed operation should present slight risks and offer considerable hope of cure of the neuralgia, although a permanent anæsthesia will be produced in those regions which are deprived of their posterior root-supply. Lastly, in some cases of malignant disease of the vertebræ in which intense pain is produced by pressure upon nerve roots, the resection of the latter will greatly relieve the unfortunate patient.

TECHNIQUE OF THE OPERATION

Several varieties of incision and variations in detail of the operation are adopted by different surgeons, but, after trying many of these modifications, I have found that the straight mesial incision with complete removal of the laminæ gives the most satisfactory results, and I shall therefore first describe this and refer subsequently to other forms of operation.

Preparation. The *preliminary disinfection of the skin* of the back presents certain special difficulties, as it is coarse and thick, with many sebaceous and hair follicles, while in many cases there may be bed-sores seriously encroaching upon the field of operation. If possible, bed-sores should be induced to heal before operating, and in all cases they should, from the time when operation is decided upon, be most carefully dressed and disinfected as far as possible, great care being taken not to allow discharges to escape through or from under the special dressing of the sore. Overflow or involuntary discharges of urine into the bed must be carefully guarded against, and it is generally wise to use the catheter frequently before and after operation. Incontinence of fæces can be temporarily controlled by the administration of bismuth and opium. The utmost care in nursing and the toilet of the bed is of course required.

The *preliminary disinfection of the field of operation* is carried out the night before by the free use of ethereal soap, turpentine (which is applied with a soft nail-brush), an alcoholic solution of mercuric chloride or iodide (1 in 500), and finally an aqueous solution compress of the same strength; but in these matters each surgeon will follow his usual routine.

Movement and position of the patient. These details having been attended to the night before operation, it is convenient to bring the patient's bed to the side of the table by means of a bed-trolley, the use of a stretcher or couch involving an additional amount of disturbance which in traumatic and some tuberculous cases may be attended with serious consequences. Bed-trolleys, although little used in British hospitals, obviate much unnecessary disturbance, and will be found highly convenient in nearly all surgical work, but especially in laminectomy.

Anæsthesia is now commenced in the bed, and when consciousness is abolished the patient can readily be lifted over on to the table, where he lies face downwards. During this preliminary anæsthesia the table is carefully prepared, as it is essential that the patient should occupy the prone position and should have ample room for abdominal respiration,

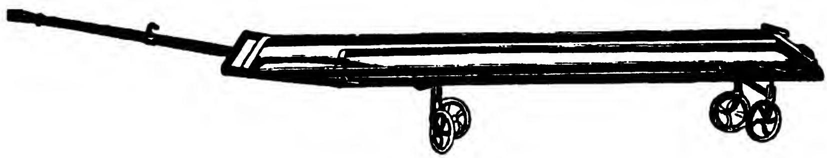


FIG. 144. BED-TROLLEY READY TO BE PUSHED UNDER THE BED.

especially in cases in which the intercostal muscles are paralysed. For this purpose a large firm sand-pillow is placed at the level of the pubes and iliac spines; a second lies under the upper chest and must be kept well below the upper margin of the sternum so as not to press upon the trachea; a third smaller cushion is adjusted to the position of the forehead. These cushions being carefully placed so as to suit the height of the patient, he is rolled over on to them, and the mouth, throat, and abdomen will then be found to be quite free from pressure. In a few cases in which the lesion lies high in the cervical region and is lateralized, the fully prone position may be modified, and the pillows adjusted so that the patient lies semi-prone, thus giving the maximum of freedom to a probably embarrassed respiration, and allowing of more complete fixation of the head and neck. In this way I have been able to operate under full anæsthesia even when the

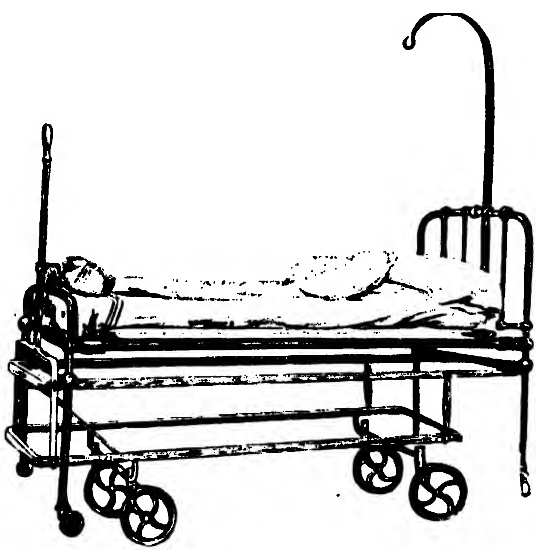


FIG. 145. BED-TROLLEY IN POSITION FOR CARRYING THE BED.

diaphragm was so far paralysed that no abdominal respiratory movements could be detected.

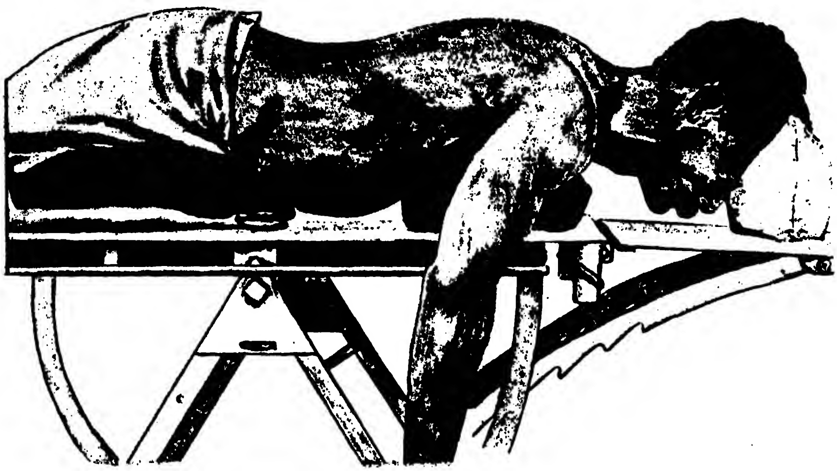


FIG. 146. ATTITUDE FOR LAMINECTOMY IN THE DORSAL AND LUMBAR REGIONS. The arms would rest upon the table, but are here drawn hanging down to show the space allowed for respiration.

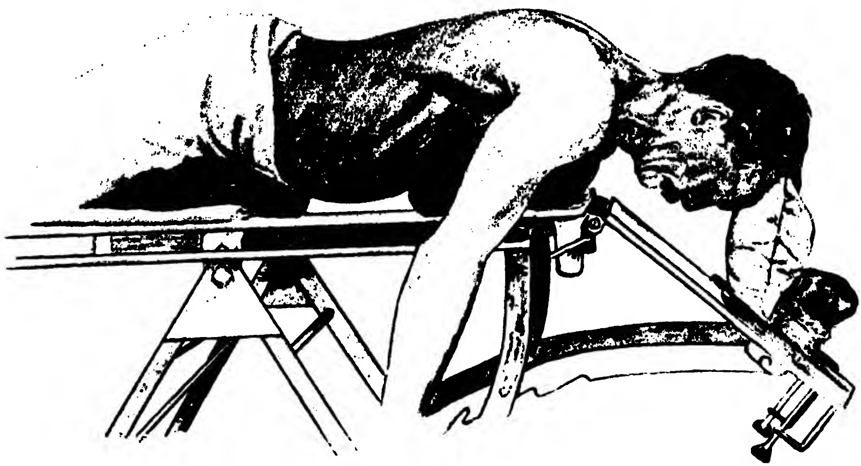


FIG. 147. ATTITUDE FOR LAMINECTOMY IN THE CERVICAL REGION. The neck is flexed more fully than in the previous figure. The arms should rest upon the table.

Anæsthesia. General anæsthesia will probably be adopted in nearly all cases, as the operative manipulations are necessarily severe, but in some cases of 'two-stage' operations the second stage has been performed without an anæsthetic, the dura mater being but little painful on section

(Abbé), and Fisher has twice operated under cocaine in cases of fracture in which the administration of a general anæsthetic was feared. Chloroform appears to me to be undoubtedly the most convenient anæsthetic, as no large face apparatus can be used with the patient in the prone position, and pieces of lint are much more readily manipulated. Of late I have also used oxygen when required, the tube from the cylinder being easily brought to the patient's face; or the Roth-Dräger apparatus may be employed. The anæsthetist should be experienced, and may have to face the most serious difficulties: respiration is often greatly embarrassed by paralysis, and there may be extensive bronchitis: the face is only partially visible: the pupils are difficult to see, and, in cervical cases, may present persistent contraction due to paralysis of the dilator iridis: where there is much bleeding or where much lotion is used, even drowning has to be guarded against: the anæsthesia must also be deep until after the removal of all bone. Under these circumstances it is not perhaps surprising that several cases have died from the anæsthetic.

Final preparation of the field of operation. The patient being now securely placed upon the table and its cushions, the dressing over the bed-sore, if present, is inspected to ascertain that it is clean and not displaced, and the compress is then removed from the field of operation. The latter area is then again cleaned with turpentine and an alcoholic followed by an aqueous solution of mercuric iodide or chloride. Small suppurating follicles are often present, and are touched with the Paquelin or other cautery. Finally, the back is covered by a dry sterilized sheet having an aperture over the seat of operation, and it is convenient to secure this in position by sutures passed through the sheet and through the skin of the back at the corners of the aperture.

Instruments required. The instruments are of great importance, and should be strong and well made, it being quite impossible to operate easily unless bone forceps and the like are well suited to the purpose. For dividing skin and muscles we require a strong large-bladed knife, resembling a post-mortem knife rather than the ordinary scalpel, and allowing of powerful sweeping through muscles down to bone; for the deeper incisions it is convenient to use a square-ended resection knife which can be firmly applied without any risk of penetrating between the laminæ. A small very sharp tenotomy knife is required at a later stage. Half a dozen pairs of hæmostatic forceps will probably suffice. The retractors must be adapted to a deep wound, and two pairs will generally be required to give a full exposure. Strong scissors are required for dividing powerful ligaments, and fine 'iris scissors' are useful for cutting the theca or dividing nerve roots, the blades of these being set at an angle of about 135° to the handle. Dissecting forceps, fine toothed for-

ceps for handling the dura mater, and two or three pairs of fenestrated artery forceps for holding the edges of the cut theca are also required, as well as strong sequestrum forceps for tearing away fragments of bone. For sawing, Horsley's saw (see Fig. 148) or Doyen's guarded saw (see Fig. 149) may be employed: in some of the 'osteoplastic' methods Gigli's saw is used, but in ordinary laminectomy it is not needed. The bone-cutting forceps should be of the prismatic type, and it is advisable to provide two straight pairs, one very large and powerful (see Fig. 150), and one smaller (see Fig. 151), as well as two pairs (see Fig. 152) specially devised by Horsley for cutting the laminæ in a deep wound, although I

FIG. 148. HORSLEY'S LAMINECTOMY SAW.

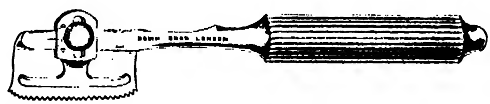


FIG. 149. DOYEN'S GUARDED SAW.

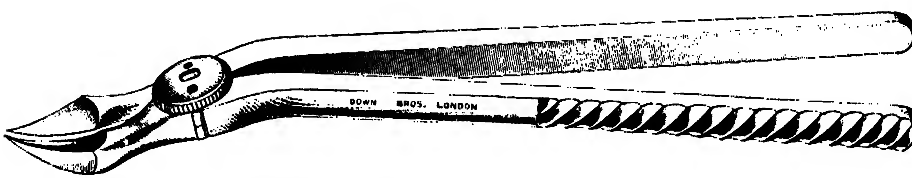


FIG. 150. POWERFUL BONE-CUTTING FORCEPS.

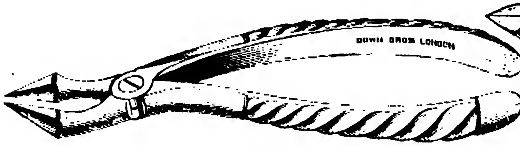


FIG. 151. BONE-CUTTING FORCEPS.

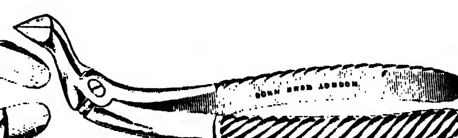


FIG. 152. HORSLEY'S ANGULAR BONE-CUTTING FORCEPS.

seldom use any but the straight ones. Powerful rongeur forceps are also invaluable for enlarging the aperture in the laminæ. The trephine I do not employ, although some surgeons utilize it to make the first opening into the vertebral canal. One or two strong raspatories are needed for clearing the bone, and a chisel is also very useful for scraping off the soft structures and leaving a clean bony surface.

For the clearing of tuberculous foci, gouges, spoons, and Barker's flushing curette are employed, and a long probe is of value in determining the extent and direction of cavities. For enucleating tumours, some form of 'blunt dissector' is required, and Horsley's aneurysm needle is useful for this purpose as well as for holding aside the theca.

Small needles for the dura mater should be fully curved, Bonney's pattern being, in my opinion, the most convenient. I use large curved

Bonney's needles for suturing muscles, and the ordinary straight surgical needle for the skin; others will prefer various patterns and possibly a needle-holder. All sutures, except silkworm-gut for the skin, are of catgut prepared according to the method of Mayo Robson or A. E. Johnson (*Lancet*, April 20, 1907), or otherwise effectually sterilized.

A douche containing a hot (115° F.) solution of 1 in 10,000 corrosive sublimate in normal saline is of great value for arresting bleeding, clearing the wound, and washing out tuberculous foci.

FIG. 153. LAMINECTOMY. *First stage.* Exposure of the ridge of spinous processes.

Operation. *Incision of the soft parts and clearing of the laminæ.* It is immaterial upon which side of the patient the surgeon stands, but the left will generally be preferred. The incision is made in the middle line of the back, and carried at once down to the spinous processes with firm strokes of the knife. It should be sufficiently long to give a full exposure of the parts, and will thus seldom be less than 6 inches in length, while subsequent developments may require it to be extended to 8 inches or more. The blade of the knife is now carried through the muscles close to the spinous processes on the side nearer to the surgeon, until its progress is interrupted by the laminæ, a few rapid sweeps separating the soft parts so as to make a deep groove on the left-hand side of the spine. No attempt should be made to deal with bleeding points, but, as soon as a considerable gap has been cut, swabs should be packed into the bleeding area and held down by the hands of an assistant. The further

side of the spine is then cleared in the same rapid and, as yet, imperfect manner, and again the groove is packed with swabs. The hæmorrhage caused by these two deep incisions will, to a large extent, cease in the course of about a minute.

We now return to the left side of the spine, the pressure by swabs being maintained upon the right, and clear the muscles more carefully from the spinous processes up to the extreme top and bottom of the incision. For this purpose a pair of strong scissors will be found convenient, and with a few cuts it will be possible to make the line of spinous processes and interspinous ligaments stand up as an isolated ridge (see Fig. 153). I have never found it necessary to make any transverse incisions in the muscles or fascia of the back, but I would insist on the importance of pushing the blades of the scissors so far upwards and downwards as to completely sever the soft parts from the spinous processes. The avoidance of any transverse incision causes less hæmorrhage, less interference with the blood-supply, and probably less subsequent weakening of the back. Swabs are again packed into the bleeding groove on the left side of the spine, and attention is turned to the right side, where the spinous processes are similarly cleared. At this stage large retractors can be introduced into the two grooves, and, the muscles being firmly drawn aside by assistants, the laminæ are well exposed. Should any large vessels continue to bleed, they may be secured by hæmostatic forceps.

FIG. 154. LAMINECTOMY. *Second stage.* Removal of the spinous processes.

Before going further, much more room is now obtained by cutting off

in one mass the whole of the spinous processes. This is done with strong bone-cutting forceps, which are best applied so as to cut from above downwards, each spine being bitten through at its base and then forcibly wrenched off until the entire line can be turned down, as shown in Fig. 156. It is quite practicable to retain the ridge of spinous processes thus turned down, and to replace it at the end of the operation, but I have never seen any necessity for so doing, and there are certain obvious disadvantages and risks, especially in the case of tuberculous lesions.

The laminæ which it is proposed to remove are now fully exposed, and the bleeding, which was at first somewhat profuse, will be to a large extent arrested. The next stage of the operation consists in cleaning the laminæ more accurately with a raspatory or chisel, arranging retractors so as to hold the wound well open, and removing any hæmostatic forceps. Ligature of vessels is rarely if ever required, and if oozing still continues the hot douche will aid in its arrest. In traumatic cases where there is recently effused blood, it is also important at this stage to express as far as possible any clots in the muscles of the back, and to make the wound as clean as possible. It is also useful to cover the sides of the wound with strips of gauze, leaving only the bottom of it exposed, but these strips are not represented in any of the drawings illustrating the operation, as they hide all but the bony structures.

The above detail is that which I generally employ, but it has been somewhat modified by various surgeons. Instead of a straight mesial incision a rectangular flap is sometimes employed, the vertical incision running down one side of the spine at about 2 inches from the middle line, while at either end a transverse incision some 4 inches long runs across the back. The parts thus marked out are raised from one side and thrown over to the other in the form of a flap, which may be made to include the spinous processes (Abbé), or may be limited to the superficial structures only, the muscles being subsequently cleared as when the straight incision is used. Some operators prefer a rounded flap turned upwards or downwards. I cannot, however, recommend these variations, except in special cases, which will be referred to immediately. They involve more damage to the muscular and fibrous structures than does the straight incision, and especially they involve transverse section of muscular fibres, unless the flap be restricted to the superficial structures. They also present the great disadvantage that it is difficult, if not impossible, to extend the wound upwards or downwards. I therefore generally prefer the vertical incision except in some tuberculous cases with marked kyphosis, in which it is convenient to commence the incision in the middle line and carry it in a wide curve round the side of the projecting spines, returning to the middle line below. By this incision a

slight flap with very broad base is raised from the skin and superficial structures only, the muscles being detached from the middle line on both sides as before.

In some operations upon the upper cervical vertebræ it is also convenient to employ a lateral or curved incision. In this region the lesion to be dealt with is often situated laterally, and before commencing the operation its position is known so precisely that the laminæ of one side only may require removal. It is also more difficult to reach the upper cervical area by a mesial incision, and this cannot be carried forwards over the occipital bone to the required depth. In such cases it is useful to employ a somewhat sickle-shaped incision, taking the form of a vertical cut 1 or 2 inches from the middle line, extending upwards until it meets the occipital region of the skull, and then curving over the occipital bone across the middle line. This allows the short thick muscles of the back of the neck to be thoroughly reflected from the affected side.

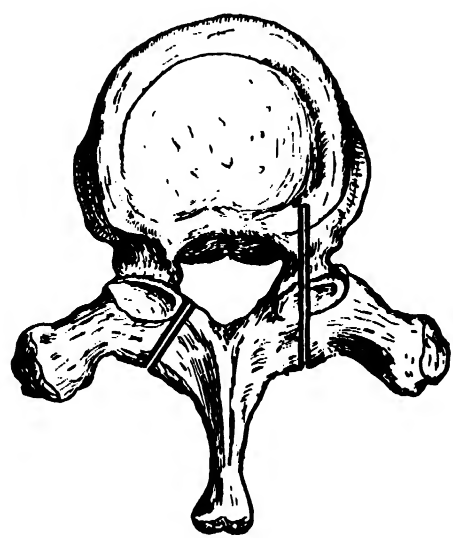


FIG. 155. DIAGRAM OF A CORRECT AND INCORRECT LINE OF SECTION OF THE LAMINÆ. (*Modified from Bickham.*)

Lastly, it is frequently advised that the soft parts should be reflected from the spine 'subperiosteally', and Ollier gives elaborate directions for this purpose. Bickham (*Annals of Surgery*, March, 1905) recommends the chisel held with its bevel towards the bones as best adapted for raising the muscles with as much periosteum as can be obtained, but it is doubtful whether any truly subperiosteal clearing of the bone is here possible, and the method above described undoubtedly yields a sufficiently firm cicatrix.

Removal of the laminæ. The laminæ to be removed having now been thoroughly cleared by the raspatory, and all superficial bleeding controlled, while the parts are well retracted, the next step is to divide the bony arches by means of the saw. For this purpose Horsley's saw is applied to the outer side of the centre of the laminæ, and the cut is carried downwards and inwards until the laminæ are almost completely divided, or the lack of resistance shows that the spinal canal has been already entered. It is most important that the section should not be made vertically, as, if the

saw is sufficiently far out in the first instance, and the cut is then made vertical, the vertebral canal will be missed altogether, and the incision will run forwards through the pedicle into the body of the vertebra, as on the right side of Fig. 155; if, on the other hand, the saw be placed at right angles to the axis of the lamina, it will penetrate towards the vertebral canal, as on the left side of Fig. 155. This preliminary sawing is easily effected in the dorsal region, when the convexity of the spine renders all the laminæ prominent. In the lumbar spine it presents greater difficulties, and it is here convenient if the surgeon can use either hand, or if the assistant is capable of sawing those laminæ which, owing to the deep concavity of the bony surface, cannot well be attacked from the left side of the patient. In the upper cervical region it is also somewhat difficult to apply the saw, but here the laminæ are so thin that they can be readily cut through by bone forceps alone, a method which is simpler and more rapid than that of sawing. In all cases in which the saw is used it is inevitable that a shallow groove should be cut in the laminæ above and below those to be removed, but this is of no practical importance.

Having made the preliminary saw-cuts, which will have penetrated to the vertebral canal, or nearly so, the bone-cutting forceps are now applied to each lamina in turn, and their division is completed, it being seldom necessary in the first instance to divide more than two. The points of the forceps should be carefully introduced for a short distance only on each side of the lamina, and should then be brought together and used to lever the bone upwards. This requires care, but the surgeon need be under no great apprehension that he will injure the theca, as there is normally a considerable space between it and the laminæ, and in disease this space will probably still be present, or, if absent, will be occupied by tuberculous tissue or tumour only. It is thus only in severe injuries and cases of caries with marked kyphosis that there is any probability of close contact between the bones and the dura mater. In traumatic conditions the lower of the two displaced laminæ should be first removed, as it is remote from the theca, which may be tightly compressed by the lamina above.

The section of the laminæ does not at once allow their removal, as they are still held by the strong ligamenta subflava, which have to be cut through with stout scissors, when the arch can be torn away by sequestrum forceps. An opening having once been made into the vertebral canal, it can, if necessary, be extended upwards or downwards by the bone-cutting forceps, and its edges are rounded off, or its area enlarged by rongeur forceps. The vertebral canal is thus fully laid open, and the further operative procedures which may be required will vary with the nature of the case, so that it becomes necessary now to consider separately—

(i) The treatment of traumatic conditions.

(ii) The treatment of tuberculous lesions.

(iii) The treatment of tumours and other compressing conditions which may or may not lie internal to the dura mater.

Treatment of traumatic conditions. The first step after having opened the vertebral canal will be the removal of any effused blood, the hot douche being used for fluid extravasation, while firm coagula are picked off or lightly scraped away by any blunt instrument. The exact nature of the injury will now be ascertained, small fragments of bone or foreign bodies being removed and tears in the dura sought for; it will also be noted whether the theca does or does not present its normal pulsation, colour, and tension. Should the latter not be torn, it is generally advisable to complete any operation upon the bony structures before opening it. The lamina which was pressing upon the posterior surface of the cord, as well as any detached fragments which may be discovered, will already have been removed. There is, however, a strong probability that the posterior part of the body of the lower vertebra will be pressed backwards against the theca, and in order to restore the full capacity of the vertebral canal this must also be removed. To do so the theca is gently raised from one side, a convenient instrument for the purpose being a curved

FIG. 156. LAMINECTOMY. Exposure and retraction of the theca by Horsley's aneurysm needle.

Horsley's aneurysm needle, as shown in Fig. 156, or a fine suture passed through the dura mater only, as in Fig. 157. In some cases it has been found necessary to divide one or two nerve roots so as to permit of still further retraction of the theca, and in the dorsal region this may certainly be done with little hesitation, the cut fibres being afterwards

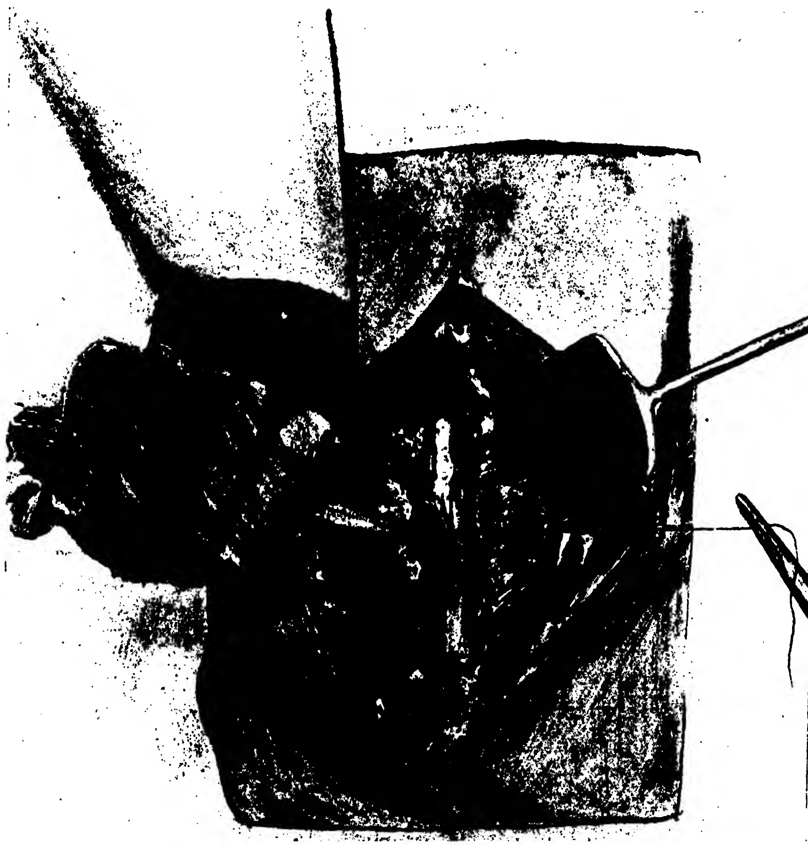


FIG. 157. LAMINECTOMY. The exposed theca is retracted by a suture passed through it, and the chisel is applied to the body of the vertebra.

sutured with fine catgut. By one or other of these means the dura can be raised up, and the projecting angle of bone clearly exposed and cut away by means of a sharp chisel, after which the same proceeding is repeated on the opposite side, and any projection completely removed.

The lumen of the vertebral canal being now fully restored, it remains to deal with the theca and its contents. If the former be already torn

open, it is not probable that it will contain any large amount of blood; if it be still closed, it must be opened by a free incision in the middle line, when any extravasation can be washed away by the douche. For the purpose of the incision in the theca the most convenient instruments are a fine tenotomy knife or cataract knife, a pair of fine toothed forceps, and a pair of iris scissors. The theca is lightly picked up, the point of the knife being introduced into it, and the section then completed by cutting with scissors, very much as in opening the peritoneum, except that, of course, the instruments required are much smaller, and ought to be very sharp.

The spinal cord itself, or its roots, are next investigated, and may be found intact, in which case nothing further need be done; or, more often, the nervous structures will be so crushed as to form a blood-stained pulp which cannot be dealt with surgically; or, very rarely, we may find a clean cut produced by a stabbing instrument. In the latter case suture has been adopted, as in the cases of Harte and Stewart and of Fowler (*vide supra*), in which chromic gut sutures were passed through the substance of the cord. Such suture should certainly be attempted, and the torn dura should, if possible, be brought together; but it is difficult to justify the excision of a bruised segment of the cord, as experience clearly shows that functional recovery may ensue even after severe bruising, while, on the existing evidence, no great confidence can be felt in suture. Abbé quotes with approval a suggestion made to him by Dana, and subsequently also recommended by Lloyd, to the effect that gaps in the medulla should be bridged over by cutting across the posterior roots of the upper segment and uniting their cut ends to the lower segment; but such an operation does not appear to have been actually practised, and there is no evidence whatever that function would be restored by it. Should the cut involve the roots of the cauda equina there is, however, no doubt as to the value and importance of suture, and successful cases have already been referred to.

The different conditions which may be encountered having thus been met, it remains only to reclose the theca and the wound, as will be described hereafter.

In *secondary operation* for old injury, it may be discovered, upon opening the spine, that the theca is firm, contracted, and devoid of pulsation; on incising the dura mater the injured region of the cord is revealed as a thin, firm band of pale tissue, which apparently contains few or no nervous elements, and which, looking like a quill, may be an inch or more in length. Under these conditions nothing further can be done. In some cases, however, a mass of callus may be found pressing upon the theca, or a dense mass of cicatrix may occupy the peridural

space, and in these the compressing agent must be excised, the prospects of recovery being much more favourable.

The treatment of tuberculosis. When the laminæ have been removed, it will often be found that the vertebral canal is occupied by a large amount of tuberculous tissue, which may be in any stage of degeneration, and it is important to notice that puriform fluid may at once escape when the laminæ are cut, and may at first sight be mistaken for broken-down nervous structure. Such a tuberculous mass, if present, renders it easy to remove the laminæ quickly and thoroughly, without danger of the instruments impinging upon the theca; but in cases of marked kyphosis the perimeningeal space may be greatly contracted, and the theca may be pressed against the laminæ as closely as in traumatic cases. The first step after the exposure of the tuberculous material will be to remove it as thoroughly as possible, and for this purpose the opening into the vertebral canal may require to be considerably extended upwards or downwards. Puriform and caseous matter can be washed away by the douche, while more solid tissue is scraped off by a small Volkmann's spoon or other blunt instrument. In many cases, especially in those of old standing, there is discovered a definite leathery mass of cicatricial fibrous tissue which may have to be excised by means of the knife and fine scissors; but in all, or nearly all, it will be found comparatively easy by ordinary surgical methods to get rid of the whole of the diseased material which lies behind and to the side of the theca, and thoroughly to clean its firm, shining, and still healthy-looking outer aspect.

It is, however, essential also to investigate and clear the anterior aspect of the dura mater. The latter is held over to one side by the aneurysm needle, as in Fig. 156, but in tuberculous disease a suture should never be used for this purpose, as it is essential not to infect the interior of the dura. Tuberculous material can now be removed from the front of the theca, as has already been done on its posterior aspect, and in many cases one or more tracts will be found to lead forwards into the bodies of the vertebræ. These tracts must be thoroughly curetted with sharp spoons, and too much care can hardly be given to this task. The abscesses or carious areas may extend far forwards, and may even be continuous with large cavities in the posterior mediastinum or abdomen. Should the conditions be such that these collections can be opened and dealt with by some route other than that which leads through the vertebral canal, such secondary evacuation is to be preferred, but where this is impracticable all that can be done is to eliminate as much as possible of the diseased material by the opening already made. One side of the theca having thus been thoroughly cleaned, the other is similarly dealt with, but it will generally be found that the disease is much more extensive

upon one side, and, fortunately, the pushing aside of the cord by exudation generally leaves a maximum amount of room upon the affected side. Throughout this stage of the operation the frequent or constant use of the douche is invaluable, and it is essential to wash away any débris which may have been scraped from the deepest parts of the wound.

The use of a drainage tube passing through the vertebral canal is not to be recommended even in the case of deeply seated and extensive foci. In a few early cases I employed such drainage, taking the greatest care to ensure that, when left in position, the tube did not press upon the spinal cord; but I am quite satisfied that it is wiser to complete the curetting and flushing of the abscesses as thoroughly as possible, and then to close the wound.

The dura mater should never be opened in tuberculous cases, as it forms a very efficient barrier to the extension of the disease to the meninges, and the destruction of this barrier can only do harm, while in the rare cases in which infection has already penetrated to the spinal cord the condition is beyond the reach of surgery.

Treatment of tumours and similar conditions. If the exposure or removal of the laminæ reveals a growth originating in bone, it will probably be malignant, and in such cases all that can be done is to partially excise or scrape it away by means similar to those adopted in the case of tubercle. I have done this on two or three occasions, and obtained very good results so far as the immediate relief of pressure symptoms is concerned, but naturally the total removal of the malignant growth has not been possible, and the patients have ultimately died from one or other of the varied results of such disease.

Non-malignant tumours in the vertebral canal, including such conditions as hydatid cysts and the masses of fatty and other tissue met with in spina bifida occulta, are generally on the posterior aspect of the theca, and may be dissected away by ordinary surgical measures. In all such cases it is unnecessary to open the theca, but removal of the compressing mass should be carried out with great care and thoroughness, and, if pulsation is not then visible in the whole of the exposed area of the theca, an intrameningeal lesion may be suspected and sought for. The results of such operations are excellent, but the occasions for them comparatively few.

The most interesting cases are, however, those in which the growth lies within the theca. In many of these nothing will be discovered until the dura is opened, although a slight bulge may be perceptible externally, and pulsation may cease at the point where the growth is situated. An incision is therefore made in the middle line of the theca with the fine

knife and scissors as already described, and this must be long enough to expose the whole of the affected area. It will be found convenient to keep open the lips of this incision by means of two fine sutures upon each side, passed through the cut edges and held back by the weight of Spencer Wells's forceps, as in Fig. 158. The tumour will then generally come into view, the majority being situated on one side of the spinal cord, and in a very accessible position, but it is to be noted that in a good many cases a cyst-like bulla of the arachnoid may first be revealed, and may be mistaken for a cyst or may overlie and obscure an actual tumour; such sacs or bullæ collapse at once on slight puncture. The tumour itself is seldom of great size, but forms a soft, rounded or oval, encapsuled mass of about the same colour and consistency as the cord itself, or darker and more vascular and often very friable. The little growth generally lies between two adjacent nerve roots, or it may involve one or even more roots in its substance, and it is seldom a difficult matter to enucleate it by gently insinuating round it the point of the curved aneurysm needle or other blunt dissector. If any roots be involved in the growth, or not readily separable from it, these may be cut across and excised without hesitation, especially as in the majority of cases they will be in the comparatively unimportant dorsal region.

FIG. 158. REMOVAL OF AN INTRAMENINGEAL GROWTH. The theca is held open by four sutures and the growth dissected away from the spinal cord.

Tumours situated in the substance of the cord have occasionally been

enucleated through a small vertical incision, and the cavities of syringomyelia, if found, may be emptied by a fine hollow needle; but such intramedullary operations do not yield satisfactory results.

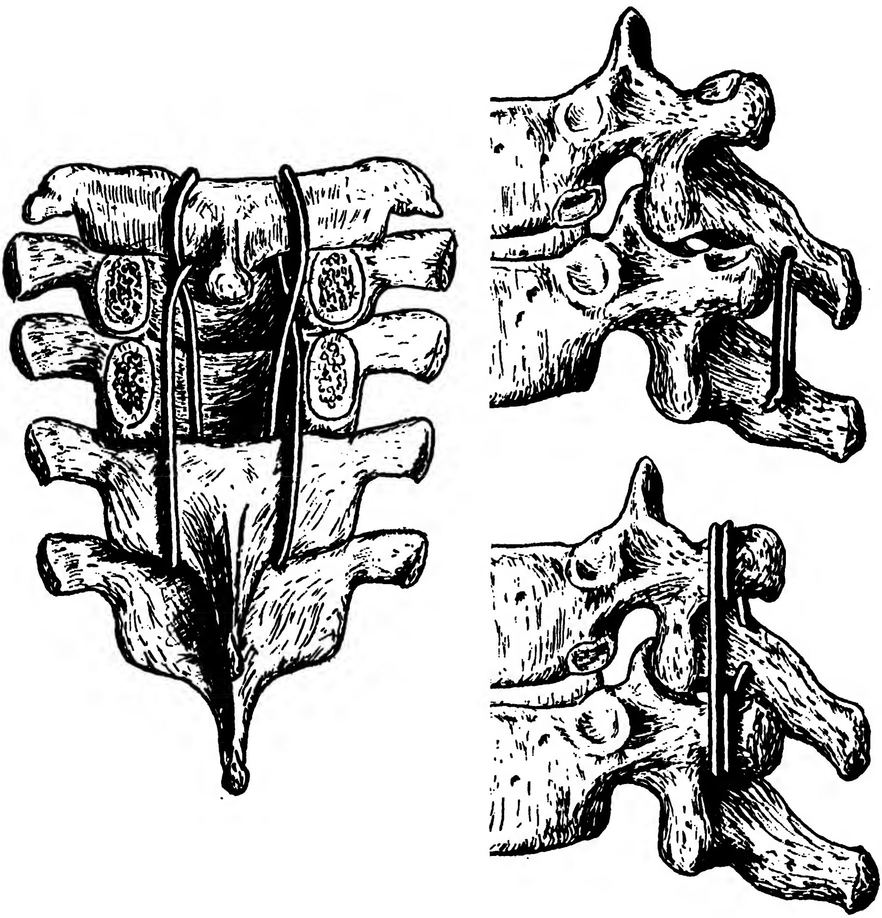


FIG. 159. METHODS OF UNITING THE VERTEBRÆ BY WIRE SUTURES. (*Modified from Chipault.*)

Closure of the wound. If the dura mater has been incised, it may be closed by a continuous suture of fine catgut, or preferably by interrupted sutures placed about ½ inch apart. The erectores spinæ of both sides are then approximated by a further series of interrupted catgut sutures, leaving the trapezius or latissimus dorsi still gaping, after which a third series of sutures brings the latter superficial muscles together,

and finally the skin is closed with silkworm gut. I have not in recent years employed any drainage, and have never had any reason to regret this course.

In order to give greater security to the spine the *wiring together of spinous processes or laminæ* has been strongly advocated, especially in cases of injury or destruction of the bodies of the vertebræ. For this purpose strong silver wire is passed through or over the spinous processes, laminæ, or articular processes as indicated in Fig. 159, modified from Chipault's *Chirurgie Opératoire du Système Nerveux.* The introduction of such methods will, however, prolong and complicate the operation, and introduces a considerable additional danger should there be any wound infection, while it would appear to be hardly necessary provided that sufficient care be taken in the after-treatment of the damaged spine. I have, therefore, never personally adopted any of these methods, although in cases of extreme osseous defect they may be of considerable value.

The wound having been closed and covered with an amount of dressing sufficient to absorb any cerebro-spinal fluid which may escape, it may be necessary to apply immediately some form of support to the spine. In traumatic and in extensive tuberculous cases this should be prepared beforehand by cutting out to the model of the patient's back a piece of the strongest poroplastic felt: in the lower dorsal and lumbar region this is made to surround the body, and where the operation is cervical or upper dorsal it encloses the shoulders and should be brought forward over the clavicles or upwards on to the occiput. Such a carapace is laid over the dressing while the patient still remains in the prone position, and is temporarily retained by one or two turns of bandage. The patient is now carefully lifted back on to the bed, which, as before, is drawn to the side of the operating table, and the support is then more securely attached by a many-tailed or roller bandage; finally, the head and shoulders are fixed by towels held in position by sand-bags.

In the great majority of cases the supine position in bed will prove the most satisfactory as well as the most comfortable, but where there is much removal of bone and any danger of pressure on the cord it is well to keep the patient upon his face.

After-treatment. In cases of prolonged operation there may be a considerable amount of shock, and for this reason many operators have divided the procedure into two stages. This is, however, very rarely necessary, and the advantages of immediate completion are obviously great. I have found little or no real difficulty in connexion with shock, and a few hours in a warm bed are usually followed by rapid recovery. Pain is often severe, but there is not as a rule any objection to the some-

what free administration of morphia. The wound is generally dressed at the end of a week, and will then be found healed. Profuse flow of cerebro-spinal fluid is an occasional inconvenience, but is certainly rare, although in some cases it appears to prolong the vomiting which follows anæsthesia ; it may be controlled to some extent by keeping the head low and raising the foot of the bed, and it may call for dressing at an earlier date than would otherwise be required ; vomiting due to this cause being probably best relieved by bromide of potassium. Details of nursing will be governed by the general conditions as regards paralysis, bed-sores, and affections of the bladder and rectum, while in some cases pulmonary complications, hyperpyrexia and the like, may have to be dealt with ; but, apart from troubles which are common to other cases of paraplegia, and are the result of the disease rather than of the operation, there is no essential difficulty in the after-treatment.

The surgical results are generally excellent, and wound healing is, as a rule, rapid and firm, the only serious difficulties being those which may result from tuberculous infection. In all ordinary cases confinement to bed for about a month will suffice, and at the end of that time the back will be sufficiently strong for the patient to sit or stand up ; but in tuberculous disease special supports may be required, and in all cases the therapeutics of paralysis or of secondary deformities, such as talipes equinus, must be carefully attended to.

OSTEOPLASTIC RESECTION OF THE SPINE

As an alternative to laminectomy 'osteoplastic resection of the spine' has occasionally been practised. The operation consists in reflecting upwards or downwards a flap which contains two or more laminæ with their spinous processes and soft parts intact, the theca being thus exposed and the flap replaced at the end of the operation. Dawbarn (*New York Med. Journ.*, 1889, vol. i, p. 711) made a vertical incision on each side of the spine, uniting the centres of these two incisions by a transverse cut so as to produce the shape of the letter H, and reflected upwards and downwards the two square flaps thus marked out, each flap containing its bony elements and being afterwards replaced. Urban (*Verh. d. deutsche Ges. für Chirurgie*, xxi[st] Congress, 1892, p. 211) introduced the operation by a U-shaped flap, which has since been improved by Hartley's suggestion to make a preliminary excision of the spinous process at its base and thus allow of more ready reflection of the flap, and the 'Urban-Hartley operation' may now be regarded as probably the best form of osteoplastic resection.

Urban describes two incisions, each parallel with and about 3 centimetres to one side of the middle line, these being united at one end by

a curved incision so as to mark out a long U which may be directed upwards or downwards. The incisions are carried down to the laminæ and the flap is then turned up from its loose end. The arch first met with is cut through close to its spinous process, where it may be attacked with the least danger to the cord; but this having been turned up, the remainder are cut as far out as possible, each in turn being raised so as to provide a clear field in which to see the next. After dealing with the contents of the vertebral canal the flap is replaced and sutured in position, the mutual relations of the soft parts of the back and the resected laminæ not having been disturbed. In the case of the lumbar and three last dorsal vertebræ the flap is turned upwards, and in that of the cervical and upper nine dorsal vertebræ it is turned downwards.

Bickham (*Annals of Surgery*, 1905, p. 372) gives a very precise description of this operation with Hartley's modification. Two distinct stages have to be recognized, *viz.* (1) the preliminary excision of the spinous process at the base of the flap, and (2) the formation and turning back of the osteoplastic flap itself. In the *preliminary operation* a short mesial incision is made at the intended base of the flap so as to expose fully, and subperiosteally if possible, one of the spinous processes; the ligaments above and below the selected spine are then cut through with scissors and a Gigli's saw is carried well down to its base, which is cut across so that the entire spine is removed; the little wound is then packed with gauze and is not closed until the end of the entire operation.

The turning back of the osteoplastic flap is then proceeded with. A fresh incision is made in the form of the letter U, the open mouth of which is the base of the flap, at which the limbs of the U turn outwards like the mouth of a flask, so as to give a wide base over the outer ends of the laminæ of that vertebra whose spine has just been excised. These limbs are carried downwards to a point below the spinous process of the last vertebra to be resected and are there united by a broad curve (see Fig. 162). The incisions thus made are carried down to bone, and should reach the laminæ internally to the bases of the transverse processes (in the dorsal and lumbar region) or articular processes (in the cervical region). The laminæ are now cleared by the chisel, the soft parts being scraped away sufficiently to leave a clear path for the Doyen's saw. The latter, with its guard set at 10 millimetres, is next carried through the laminæ to be resected and will also cut about half-way through each lamina above and below; to do this in the whole length of the wound it will be necessary for the surgeon to saw first with the right hand and then with the left, or else to walk round the patient and complete his section from the opposite side of the table, as the handle of the saw

does not allow a complete section to be made by sawing only from below upwards. The saw-cuts having been completed and carried well through the laminæ, the ligaments below the lowest exposed spine are completely divided by scissors in the usual way, and the flap is now ready to be turned back by the chisel, which is used as a lever and not as a bone-cutting instrument; it is at this stage that the advantage of preliminary excision of the basal spine is realized, as it would otherwise be impossible without much tearing to bend back the base of the U-shaped flap. The theca is thus fully exposed, and the remaining stages of the operation are similar to those of laminectomy and dependent upon the conditions met with. At the close of the operation the flap is carefully replaced and sutured in its original position.

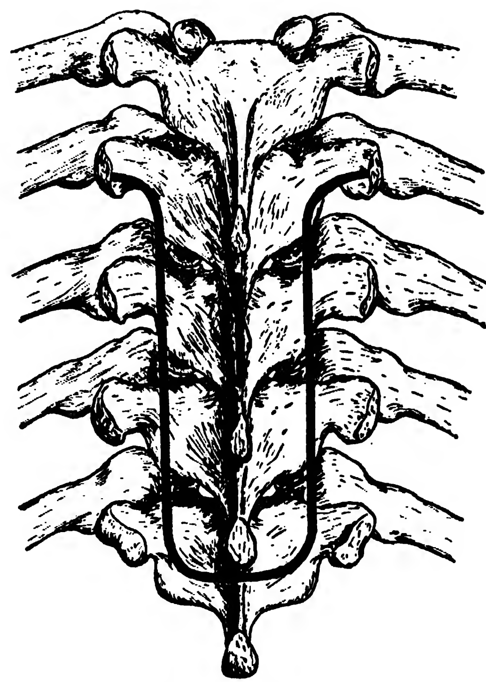


FIG. 160. OSTEOPLASTIC RESECTION OF THE SPINE. (*Diagram modified from Bickham.*)

The one great advantage of this operation over ordinary laminectomy is that practically no bone is removed and that at the close of the operation the continuity of the spine and of the vertebral canal is restored. That this is *per se* an advantage cannot be denied, although in its practical working laminectomy does not appear to lead to the weakness of the back which might be expected. On the other hand, the osteoplastic operation has certain definite disadvantages. Of these perhaps the most serious is the difficulty and danger of its performance in many pathological conditions. Bickham in his strong advocacy insists that the theca can hardly be injured, but he is careful to point out that its safety is only assured under normal conditions, *i.e.* where there is a well-marked peridural space. In injuries and in diseases of the bodies of the vertebræ with marked kyphosis such a space is often entirely absent, and I should fear to open the spinal canal by a method which gives a less clear field of view and a less range of selection in the method of dividing the laminæ, and which

depends for its safety entirely upon accurate sawing through laminæ which may be in the closest contact with the cord.

Not only does resection thus appear to be a more dangerous operation, but in many cases of disease it has certain further disadvantages. Bleeding is probably greater in an operation in which the incision of the soft parts is doubled in extent, and the time required for the operation must be greater than in laminectomy. Again, the resection operation does not readily allow of extension of the spinal opening beyond the scope originally planned. And, lastly, in cases of compression due to injury or other varieties of kyphosis the reposition of compressing laminæ may render the whole operation futile.[1]

For these reasons the writer has, after one or two attempts, abandoned osteoplastic resection, although it might usefully be employed in cases in which we have to deal with such conditions as accurately localized intrameningeal tumours or the division of roots for neuralgia, that is to say, for conditions in which the vertebral canal may be expected to be normal in size, and in which it will not be necessary to extend the field of operation.

MORTALITY AND DANGERS

The operation of laminectomy is undoubtedly a severe one in itself, but its mortality is not readily ascertained, as many cases die early from the original disease rather than from operation, and in published records it is by no means always easy to determine what the cause of death has been. Nor is it safe to draw definite conclusions from published cases alone, while hospital statistics are not available in the case of an operation so seldom performed. Harte (*Annals of Surgery*, 1905, p. 524) has, however, carefully collected ninety-two published cases of operation *for tumour* and obtains the following results. Forty-three cases (47 %) were fatal, but of these a good many died some weeks after operation, and it is probably only in twenty-six (28 %) that death could be traced to the operation, the principal causes of death being shock and hæmorrhage (seven cases), sepsis and meningitis (seven cases), and 'exhaustion' (eight cases).

Endeavouring some years ago to ascertain the mortality of the operation in various conditions, I collected the published records of a few surgeons who had had considerable experience, and had reported groups of cases. The records of Macewen, Horsley, Lane, Abbé, Chipault, Schede, and my own cases, thus yielded seventy operations for various conditions, and of these twelve, or 17·1 %, might be regarded as deaths due to or accelerated by the operation itself. Summarizing these results in the Hun-

[1] In the event of septic infection the flap with its detached bones may become a source of great danger, and Sonnenberg attributed death in one of his cases to this cause (Harte, *loc. cit.*).

terian Lectures for 1894, I added: 'The cause of death in these cases was generally shock; septic troubles are practically absent, and hæmorrhage, formerly so much feared, is rarely serious. This fact is an encouraging one, as it is by no means impossible that an increasing experience and possibly an improved technique may lessen the one serious risk—that of shock.' That this has proved to be the case my own experience has since confirmed, as I have now personally operated forty-nine times and obtained the following results :—

Operation for	*Total cases.*	*Deaths due to or hastened by operation.*[1]	*Deaths due to the disease but occurring within a few weeks.*
Recent injuries	5	0	5
Old injuries	17	1	0
Caries	17	2	1
Malignant bone disease	3	0	1
Extra-medullary growths	2	0	0
Intramedullary growths	4	0	0
Exploration (? acute myelitis)	1	0	1
	49	3	8

In the above table we find then only three deaths (6·1 %) which were more or less directly due to the operation, and of the three deaths two were in cases of advanced tuberculous disease with extensive destruction of the vertebral bodies, both dying from shock, while the third was due to a re-extension of traumatic myelitis in a case of cervical injury with almost complete paraplegia in which operation was undertaken eight weeks after the infliction of the injury. Exploratory operations and operations for tumours and allied conditions have been uniformly successful so far as life is concerned, and even in the earlier and more tentative operations for injury, which have now to a large extent been abandoned, there has been no reason to suppose, except in the one case referred to, that death was in the least degree hastened by operation.

It would therefore appear that laminectomy *per se* is a formidable operation, but far less so than it is often supposed to be, and that, except in very severe cases, the immediate result ought to be quite satisfactory. There are, however, certain special difficulties and dangers which demand somewhat further consideration.

Shock is often severe, and is due mainly to the prolongation of the operation and to hæmorrhage. It is therefore best avoided by familiarity with the technique, the use of thoroughly suitable and reliable instruments and especially of effective bone-cutting instruments, the efficient arrest of bleeding, and care in the warming of the operating theatre and

[1] None of these deaths have occurred in recent years, nor have there been any bad results in three cases operated upon since the above was written.

in protection of the body temperature by wrapping up the limbs. The division of the operation into two stages offers much less advantage than in operations upon the skull. In cases of injury such division will rarely be contemplated, as the conditions are comparatively simple, the localization is easy, the treatment of the bony lesion is usually the sole consideration, and the only hope of success lies in the relief of the lesion at the earliest possible date. In the case of tumours also, the operation, if divided into two stages, would be interrupted before the incision of the theca, but this incision and the enucleation of a growth seldom take any great length of time or cause any serious hæmorrhage or shock. In tuberculous cases with extensive abscesses the difficulties and delays may be great, but unfortunately these cases are ill suited to a two-stage operation which increases the already grave risk of infecting the wound with tuberculosis. For these reasons I have never thought it wise to divide the operation. One of the two cases which died from shock was that of a child in which the removal of the laminæ revealed the fact that the bodies of the vertebræ were totally destroyed, so that all the support of the spine was withdrawn, and in the other a large abscess penetrated to the pleura, neither of which are conditions likely to have given better results had the operation been thus divided.

As a rule, even severe shock after laminectomy passes away readily when the patient is returned to a warm bed. The usual stimulants may be given by the mouth or by hypodermic or intravenous injections, and there is no difficulty, such as is met with in abdominal operations, in giving food and stimulants by the mouth. On the other hand, it is advisable not to give rectal injections if they can be avoided, as the rectum is often incapable of retaining them, while there is considerable risk of soiling the dressings and it is advisable to disturb the patient as little as possible.

The *anæsthesia* presents very considerable difficulties, and in several reported cases death has resulted from the anæsthetic. This question has, however, already been fully dealt with, and it is only necessary to reiterate the importance of providing for the free use of such muscles of respiration as can act, combining oxygen with chloroform, and, in operations upon the upper spine, guarding against the entrance of fluid into the respiratory passages.

Hæmorrhage is very free at the time of incising the muscles of the back, and is naturally the most prominent danger at the moment of operation. The best safeguard is to make the incisions into muscle freely and quickly, and then to plug the wound with swabs, allowing a short time for pressure to effect arrest. If this be done it will be found that after a very few minutes only one or two bleeding points remain, and that these can readily be secured. I have never required more than half a dozen

hæmostatic forceps and have seldom had to use any ligatures. The use of adrenalin has been advised, but is probably quite unnecessary and causes some additional delay and risk of infection; calcium chloride administered in half-drachm doses thrice daily for forty-eight hours before operation might be of service, but I have only recently employed it in laminectomy, and cannot at present claim any special advantage from its use; the hot douche is of great value in checking bleeding during the later stages; but my sheet anchor is undoubtedly sponge pressure throughout the operation. Flap operations and methods which involve any transverse section of the muscles of the back are obviously more liable to be associated with serious bleeding, for which reason the long straight incision of all muscles is probably much the safest. Chipault has collected three cases of death due to hæmorrhage from the vertebral artery, but such results appear to indicate a want of precision in anatomical knowledge, as, if the operation approaches the transverse processes of the cervical vertebræ, the artery ought to be tied. Secondary hæmorrhage appears to be unknown, and the position of the wound causes so much local pressure that we need probably have no fear of continued oozing.

Sepsis has seldom given trouble, and the measures which have been found most effective in its prevention have been already indicated. Von Bergmann advises stitching oiled silk to the edges of the skin wound, followed by resterilization of the hands before proceeding with the operation, but gauze is probably quite as effective and is much more efficient in arresting hæmorrhage.

Escape of cerebro-spinal fluid has in the past been regarded as a special danger of the operation, but does not appear to have been actually fatal in any case either of operation or of accidental injury to the meninges. If troublesome at the time of operation it may be controlled by lowering the patient's head, but the flow is rarely sufficiently profuse to cause any inconvenience. It is usually at once arrested by suture of the dura mater, and it is quite unusual to find any appreciable amount of discharge on the dressings.

Injury to the contents of the vertebral canal must of course be most carefully guarded against, and extreme care and gentleness are necessary in removing the laminæ and in handling the cord. In the normal spine there is a considerable interval between the arches and the theca, this space being occupied only by a little lax tissue with some fat, and it is here easy to introduce the ends of bone forceps into the canal and to cut freely. In the case of intrameningeal tumours there is also generally abundance of room, but the perimeningeal space is apt to be slightly lessened and its connective tissue is often increased in density and less obviously fatty. In tuberculous cases with no marked kyphosis there is

also a wide space, and the tuberculous material which occupies the space serves to protect the theca during the manipulations for its exposure. Similar conditions will also be met with in the case of extra-meningeal tumours.

It is thus in the case of injury and of some tuberculous spines with marked kyphosis that the greatest difficulty is met with, as in these the lumen of the vertebral canal may be greatly restricted and the utmost care is required in removing the laminæ. The safest course is to make the first opening not through the most depressed lamina, but through the prominent one beneath it, so that the exact position can be more clearly seen and the available space estimated. In the subsequent section of the compressing lamina the saw is used with great care and carried only partially through the bone, after which the bone forceps are applied vertically, no attempt being made to insinuate one point beneath the bony arch.

It is obviously very necessary not only to avoid injury in removing bone but to guard against pressing on the theca with swabs, and assistants must be warned and most carefully watched to prevent any rough use of sponges, to which they are the more prone as in the early stages of the operation firm pressure has been a necessity. It is also essential to use the utmost gentleness in raising the theca to attack its anterior aspect and in enucleating intramedullary growths.

In spite of all possible precautions I have had two cases of tuberculous disease with marked spastic paraplegia in which operation was followed by a complete flaccid paraplegia with anæsthesia, and in which the cord must have been injured by the operation, but I do not know exactly how such injury was inflicted, as it may have been due either to direct bruising or to subsequent pressure by blood or by the escape of the contents of tuberculous abscesses. I do, however, consider that the very real danger of increasing the injury to the spinal cord is one of the most serious in operating upon advanced tuberculosis, but have never met with this difficulty in any other class of case.

Interruption of the continuity of the spine is also a real danger in cases of severe injury and in advanced tuberculous disease or malignant growths of the bodies of the vertebræ. In such cases the bodies may be so completely destroyed that on removal of the laminæ there is no sufficiently firm tissue left to maintain the integrity of the column, and there is the greatest danger that the cord will be crushed in moving the patient, or that the back will not again be fit to carry the body weight. In traumatic cases and in malignant disease such a result would be of little importance, as life could not be prolonged under any circumstances, but in tuberculous disease it may aggravate the pre-existing trouble. It is therefore advis-

able, in cases of Pott's curvature with marked deformity, to ascertain by radiography whether the bodies of the vertebræ are still sufficiently well defined to be reasonably likely to maintain their continuity. I would also advise that the operation should be discontinued if on exposure the laminæ are found to be ankylosed. In the case to which I have already referred, in which laminectomy left no bony continuity in the spine, and in which fatal shock ensued, I found three laminæ thus firmly ankylosed, and having removed them discovered that the spine was left absolutely flaccid and incapable of yielding any protection to the spinal cord or any support to the body.

Tuberculous infection of the wound or cicatrix is best avoided by the thorough removal of the disease at the time of operation, but will probably always constitute a serious difficulty in this as in other operations for tuberculous bone disease. The danger is probably increased by drainage, which should therefore be avoided whenever possible, but if evacuation of an abscess cavity can be effected by some route other than the spinal canal such a 'safety-valve' should certainly be provided. The danger of tuberculous invasion of the scar may also be diminished by the use of a slight flap in cutting the superficial structures, and this has the advantage of leaving intact the frequently damaged skin over the angle of curvature. The flap is taken in a gentle curve round the prominent angle, leaving and returning to the middle line; it goes through superficial structures only, and after it has been reflected the muscles are divided by the usual vertical incisions.

Weakening of the back so that it is permanently unable to support the weight of the head or body has been occasionally met with, but is probably best avoided by keeping all muscular incisions absolutely longitudinal and by closely suturing the muscles together at the end of the operation. If this be done a very firm scar is secured, and the writer has never seen any inconvenience result from weakness, while many patients are able afterwards to carry on laborious work without any inconvenience. In tuberculous cases it is of course necessary to treat the bone disease after operation, and, as in all other cases of spinal caries, the results may be unsatisfactory; in traumatic cases it is also advisable to support the spine for about two months after the injury; but in the case of tumours and of operation upon old traumatic cases no support is required, and the back is quite strong enough for the patient to sit and stand up after three or four weeks, which is probably the shortest time at which his paraplegia would permit him to do so. Speaking broadly, the results as regards the strength of the spine are so satisfactory that it is rarely if ever necessary to adopt any osteoplastic operation or to secure the laminæ by wire sutures.

RECOVERY OF FUNCTION AFTER OPERATION

Even more difficult than an estimate of the inherent dangers of laminectomy is an appreciation of the results as regards the recovery of function of the spinal cord, nor can any certain information be obtained from an analysis of published cases. The following analysis of personal cases will, however, give some indication of what may be anticipated in a fairly large number and representative series of operations, it being premised that in all these cases the lesion was a severe one. The cases are forty-nine in number, and we have already seen that three died as a result of operation, so that there remain for consideration forty-six. These may be roughly divided into groups as follows: (*a*) cases which died as a result of the original disease or injury within a short period of operation; (*b*) cases which survived but which when discharged from hospital or otherwise lost sight of were unrelieved; (*c*) cases which presented marked improvement in symptoms but in which symptoms are known to have ultimately returned; (*d*) cases which when discharged from hospital or lost sight of were markedly relieved or improving, but were not actually traced to recovery—this column includes three cases which have been operated upon within the last six months and which can therefore not be traced to the final result; (*e*) cases which have been definitely traced to recovery sufficient to allow the patients to return to work.

Pathological condition.	*Cases.*	(*a*) *Death from disease.*	(*b*) *Unrelieved.*	(*c*) *Relieved but recurring.*	(*d*) *Relieved.*	(*e*) *Cured*
Recent injuries .	5	5	0	0	0	0
Old injuries . .	16	0	5	0	7	4
Caries . . .	15	1	3	5	2	4
Malignant bone disease	3	1	2	0	0	0
Extra-meningeal growths.	2	0	0	0	0	2
Intrameningeal growths .	4	0	0	0	1	3
Exploratory (? myelitis) .	1	1	0	0	0	0
Total . .	46	8	10	5	10	13

From the above table it will appear that, roughly speaking, one-fourth of the cases may be regarded as cured, and one-fourth as relieved, the remaining half not having benefited from operation. We also find, as is to be expected, that in recent injuries, in malignant bone disease, and in exploration where no tumour was found, there were no good results. In old injuries the removal of callus or of cicatrices around the theca has proved very valuable, and in cases of tuberculosis with abscesses or cicatrices pressing upon the cord the results have also been satisfactory,

while in the case of tumours they have been very good. In effect this implies that in all cases of pressure lesion we have much to hope for, but that in acute cases success must be rare, while malignant disease can seldom if ever be eradicated.

Analyses of published cases give little information of value. The number of operations performed for injury has been great, and many are stated to have been relieved or cured, but in a very large number of these such expressions merely imply that the case was not rapidly fatal, and only a detailed examination of each would show how far real recovery was obtained or was attributable to operation; the majority of the records will be found to be very unconvincing. Again, in the case of paraplegia due to caries large numbers of recoveries can be obtained by early operation in all cases, but so many of these recover with prolonged rest in bed that it is not safe in all cases to assign the results to the operation. In the case of tumours we are, however, upon much safer ground, as it may well be assumed that all would have been fatal but for operation, and there need therefore be no hesitation in accepting as 'cures' those published cases in which tumours were removed and a good functional result ensued. Harte (*loc. sup. cit.*) has collected ninety-two of these operations of which forty-nine survived for at least some months, and of these forty-nine he finds that twenty-nine, or 31% of the whole number, were 'cured', seventeen (18%) were 'improved', and three only (3%) were unrelieved. These figures probably give a fair picture of the prospects of cure in the case of tumours of all kinds, but the tables include a few such cases as those reported by Macewen of old tuberculous disease with thickening around the theca. Williamson (*Diseases of the Spinal Cord*, London, 1908, p. 174) has collected fifty-one successful operations, to which we may add six personal cases, of which four have recovered and two are steadily recovering, but of recent date, as well as five cases of hydatid cyst operated upon by Armour (*Lancet*, 1908, vol. i, p. 838), with 'recovery and decided improvement so far as they were able to be traced', making in all sixty-two cases of recovery, and on this basis we may fairly look forward in future to obtaining good recovery in a considerable number of cases, and probably in at least one-third of those operated upon.

Such recovery is unfortunately generally marred by the development of degenerative changes before the operation, and there can be no question that increasing confidence and earlier diagnosis and operation will give progressively better results.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART I

OPERATIONS UPON THE KIDNEYS AND URETERS

BY

DAVID NEWMAN, M.D. (Glasg.)
Surgeon to the Glasgow Royal Infirmary

CHAPTER I

THE REGIONAL ANATOMY OF THE KIDNEYS AND URETERS

ANATOMY OF THE KIDNEY

THE measurements of the kidney may be stated as 4 inches in length, $2\frac{1}{2}$ inches in breadth, and $1\frac{1}{4}$ inches in thickness. The left kidney is generally longer, narrower, and thinner than the right. The shape of the kidney varies greatly in individuals, and also according to age. The normal fœtal kidney is distinctly lobulated, and this condition not infrequently persists in a minor degree in adult life, the surface of the organ being more or less deeply fissured and divided into distinct portions. The surface of the living normal kidney is of a greyish red colour, but the exact appearance depends upon the quantity and the character of the blood contained in the organ.

The kidneys are convex on the upper, outer, and lower margins, and on their inner border they have a short abrupt concavity or notch—the hilum—into which the renal arteries enter, and through which the veins and ureters pass out. In consistency, the kidneys are firm and elastic, but the parenchyma is brittle and easily torn. The anterior surface, while more round than the posterior, is somewhat like a flattened wedge. Frequently a prominence or rounded ridge extends across the anterior aspect, from which the surface slowly falls away obliquely, forming two indistinct planes. On the upper plane of the left kidney rests the stomach, the spleen, and the suprarenal body; on that of the right, the liver. The lower planes press upon the intestines (large and small), especially the duodenum on the right side. They look slightly outwards, and are partly covered by peritoneum.

The posterior surface of the kidney is flattened, and is directed slightly inwards as well as backwards; it may also be marked by the pressure of the muscles when these are well developed and the adipose capsule is deficient, and even the ribs and vertebræ sometimes leave impressions. The posterior surface is not covered with peritoneum, but rests upon the twelfth rib on the right side and the two lowest ribs on the left; between the kidney and the transverse processes of the first and second lumbar vertebræ are interposed the anterior layer of the lumbar

aponeurosis, the quadratus lumborum, and the psoas muscles. Behind the kidney, but separated from it by the diaphragm, is the pleura, which descends as low as the upper surface of the twelfth dorsal vertebra and the lower margin of the eleventh rib.

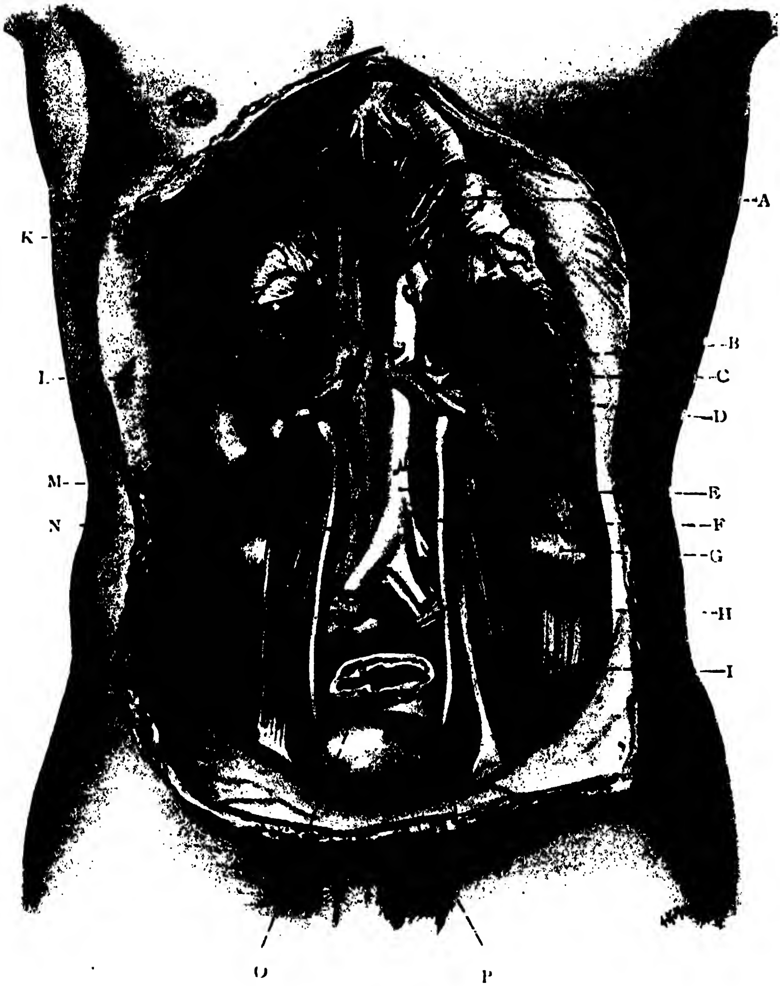


FIG. 161. THE RELATIONS OF THE KIDNEYS. Drawing showing anterior view of the kidneys, C and L, in position, and their relationship to the diaphragm, K, and the muscles of the back. H, Psoas muscle, and I, Iliacus; G, Ilium, M, Vena cava, and D, Left renal vein; E, Aorta, and B, Left renal artery; N, Right, and F, Left ureters; P, Bladder, and O, Rectum; A, the opening in the diaphragm for the œsophagus.

It is to be observed that the kidney does not lie directly in the vertical plane of the body, but its outer border is rotated slightly backwards, so that the anterior aspect looks outwards as well as forwards; nor is the short axis of the kidney parallel with the horizontal axis of the body.

The upper poles of the kidneys, but especially that of the right organ, are rotated towards the vertebral column, and, as a consequence, the hilum looks slightly downwards as well as inwards. The hilum is about $1\frac{1}{2}$ inches from the middle line of the body, and the external border about $2\frac{1}{2}$ inches further out. To the surgeon, the structures which enter the hilum of the kidney are of considerable importance, as they practically form the pedicle in cases of nephrectomy, and their relationship is of moment in all operations on the kidney; they are the renal arteries, the veins and the ureters, the nerves and the lymphatics.

The vascular supply to the kidney is very abundant, the arteries being large in proportion to the size of the organ. The right artery is longer than the left. Both arise from the aorta about the same level; the right artery passes behind the vena cava, and just before entering the hilum it passes between the ureter and the renal vein before breaking up into three, four, or five branches, to be distributed to the substance of the kidney. Deep in the sinus of the kidney these branches subdivide into smaller vessels which, leaving the sinuses, penetrate the substance of the organ between the papillæ, and these by dividing and subdividing reach the bases of the pyramids, where they form arches between the cortical and medullary parts. Occasionally small arterial twigs penetrate the cortex of the kidney at a considerable distance from the hilum. These small arteries may be branches of the renal artery, or may be from an independent source, such as the aorta, the lumbar, the internal, external, or common iliac, or the right hepatic arteries. Sometimes these supernumerary arteries enter the kidney at the hilum, but as a rule they penetrate the cortical substance directly.

If the ureter be traced upwards to the kidney, it will be seen to expand as it enters the fissure into a funnel-shaped dilatation, which, however, loses its conical form. As viewed externally, the pelvis appears as if it were a single sac, but if a section of the cortex be made, and the parenchyma removed without opening into the cavity of the kidney, the pelvis as it enters the sinus will be found to divide into two or three primary branches, which in turn subdivide and end in short truncated but wide branches; these are the calyces infundibuli, which receive the papillæ into their outspread mouths. The calyces are connected with the bases of the papillæ. Not uncommonly the infundibula are so wide that they surround two or sometimes even three papillæ; hence the papillæ are more numerous than the calyces. The external fibrous covering is continuous with the

capsule of the kidney and the pelvis and ureters contain a few muscular fibres, which are both circular and longitudinal, being continuous with the muscular layer of the ureter. The mucous membrane is continuous with that of the ureter, and the epithelial layer is reflected over the summit of each papillæ. The sinus of the kidney is occupied by a quantity of fat, which fills the spaces between the calyces, and embedded in it are seen the branches of the renal vessels.

The adipose capsule is derived from the lamina fibrosa of the fascia propria peritonei, and is composed of loose tissue, which on reaching the kidney divides into two layers and contains a variable quantity of fat. These two layers divide, one passing in front of the kidney, between it and the peritoneum, to which it is united; the other, extending behind the pelvis and vessels, is in close contact with the posterior surface of the kidney, contributes largely to the fixation of the organ, and has been termed by Barthol the 'ligamentum suspensorium renis'. The perirenal fascia has an anterior and a posterior lamella, and these join to be inserted into the diaphragm. Fat is deposited both in front of and behind the posterior lamella. According to Zuckerkandl, the perirenal fascia is strengthened on the left side by numerous bands, remnants of the primitive fusion of the descending colon and the parietal peritoneum. Owing to the difference in the relationship of the colon, this additional support is wanting on the right side. The perirenal fat differs in colour and density from that found elsewhere; it is of a finer texture and a bright yellow colour, and so can be distinguished easily from the subperitoneal fat. As a rule, the adipose capsule is most abundant close to the hilum or on its posterior aspect. Through the mass of fat distinct strands of fibrous tissue pass between the fibrous capsule and the perirenal fascia, but, according to Delitzin and Walkow, they are not strong enough to give much support to the kidney; they seem to act simply as stays to maintain the organ in its relative position. When the upper strands are lengthened or wanting, the kidney falls forwards, and the upper segment is flexed upon the lower, producing a condition described by Potain under the name 'anteversion of the kidney'. While in the normal kidney these bands are recognized with difficulty and their physiological importance may be questioned, in many cases of movable kidney they are very distinct; the question may, however, be raised whether the bands seen under such circumstances are normal or due to the stretching of the adipose capsule.

In health one always finds the organ closely packed in adipose tissue (see Figs. 162 and 163), so that the retrorenal fascia (H) can be exposed only by cutting through a deep layer of fat (O) lying posterior to it, and, after dividing the fascia, the firm fat (G) must be torn away

before the kidney is reached. In movable kidney, while a considerable amount of fat remains, it is loosely bound together, so that its meshes may be separated and the surface of the organ exposed by the finger alone. In many cases which have come under my notice, the absorption of fat has been very marked, and the sac in which the kidney moved has become so loose that it could be easily dragged out into the wound. Frequently, in those of old standing, the fat becomes infiltrated with loose connective tissue, which makes it tough and fibrous, so that when this altered capsule

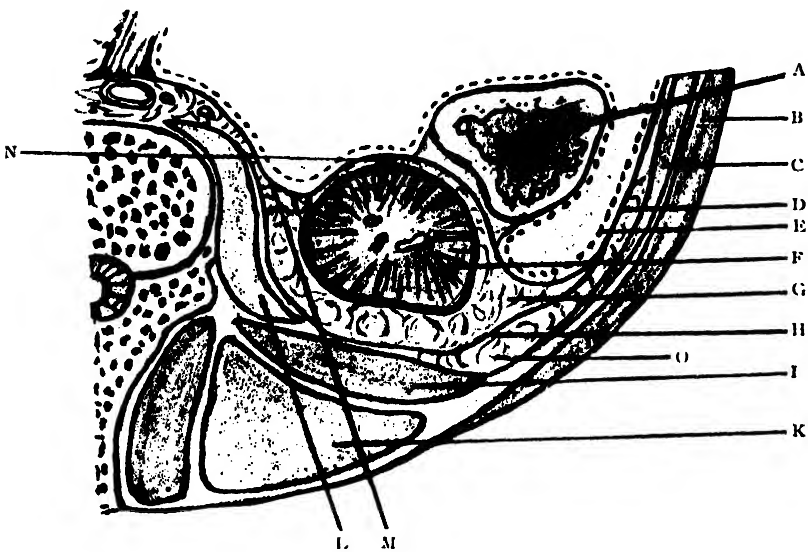


FIG. 162. TRANSVERSE SECTION THROUGH THE RIGHT LUMBAR REGION. A, Descending colon; B, Internal oblique; C, Transversalis; D, Subperitoneal fascia; E, Peritoneum; F, Right kidney; G, Fat within the perirenal fascia; H, Posterior lamella of the perirenal fascia; I, Quadratus lumborum; K, Erector spinæ; L, Psoas; M, Anterior lamella of the perirenal fascia; N, Fat between the perirenal fascia and the kidney; O, Fat behind the perirenal fascia.

is stitched to the parietes, the kidney can be maintained in its position without suturing the organ itself.

The perirenal fascia, which in health is a thin prolongation of the subperitoneal fascia (see Figs. 162 and 163), is the most important structure employed in retaining the organ in its normal position; divided into two lamellæ—the anterior (M) and the posterior (H)—the fascia in normal conditions is embedded in fat, the layer in front of the kidney (N) being thin, while that lying posteriorly (O) is usually thick. In cases of movable kidney, the lamellæ of the perirenal fascia may become greatly thickened and fibrous, and the sac formed by them considerably

enlarged. After separating the layer of fat situated behind it, the fascia when exposed may be seen as a large loose fibrous sac, within which the kidney freely moves, only a small quantity of adipose tissue being interposed between it and the surface of the kidney.

The fibrous capsule is formed of thin connective tissue which firmly and closely surrounds the kidney. The thickness of this capsule varies greatly; in some instances it is as thin as peritoneum, easily torn, and gives a very insecure fixation for sutures, while in others it is strong and firm, and is not easily torn. It possesses a certain degree of elasticity, so as to permit some stretching or shrinking, according to the vascular condition of the organ; under normal conditions it can be readily separated from the cortex, to which it is united only by minute processes of connective tissue and by small blood-vessels; in disease, however, the fibrous capsule may become considerably thickened and firmly adherent. The external layer is composed almost entirely of connective tissue, but the deeper or cortical layer contains some unstriped muscular fibres. From the surface the capsule follows the hilum, and passing inwards becomes continued along the bases of the pyramids with the strong external fibrous and elastic tissue of the calyces and pelvis.

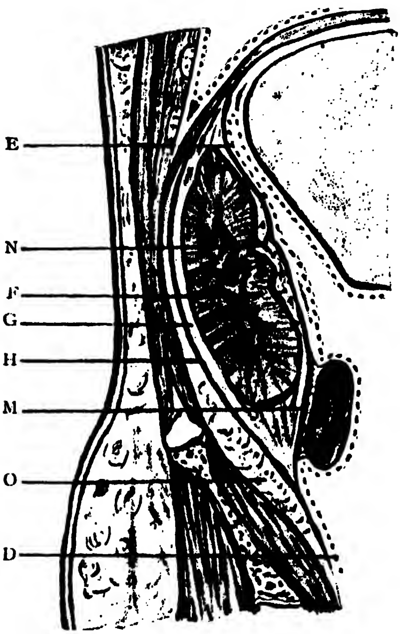


FIG. 163. VERTICAL SECTION THROUGH THE RIGHT LOIN. D, Subperitoneal fascia; E, Peritoneum; F, Right kidney; G, Fat within the perirenal fascia; H, Posterior lamella of the perirenal fascia; M, Anterior lamella; N, Fat between the anterior lamella and the kidney; O, Fat behind the perirenal fascia.

The kidneys, situated behind the peritoneum, one in each lumbar region, are embedded in capsules of fat, and are retained in position by the vessels which pass to and from them. The right kidney is generally situated a little lower than the left, probably as a consequence of the vicinity of the large right lobe of the liver. The kidneys are placed on either side of the vertebral column, about the level of the last dorsal and upper two lumbar vertebræ; their position, however, is very liable to variation, both in health and in disease, and also according to the conformation of the skeleton. Perhaps no organs in the body vary more in their position than the kidneys. Their relative distance from

the spine, or their position in relation to other organs, is observed to vary considerably. For instance, without any evident cause, one may be found close up to the spleen, touching the diaphragm and vertebral column, while the other is situated considerably below the crest of the ilium, and at some distance from the spine. From observations made regarding this point, it seems clear that malposition of the kidney,

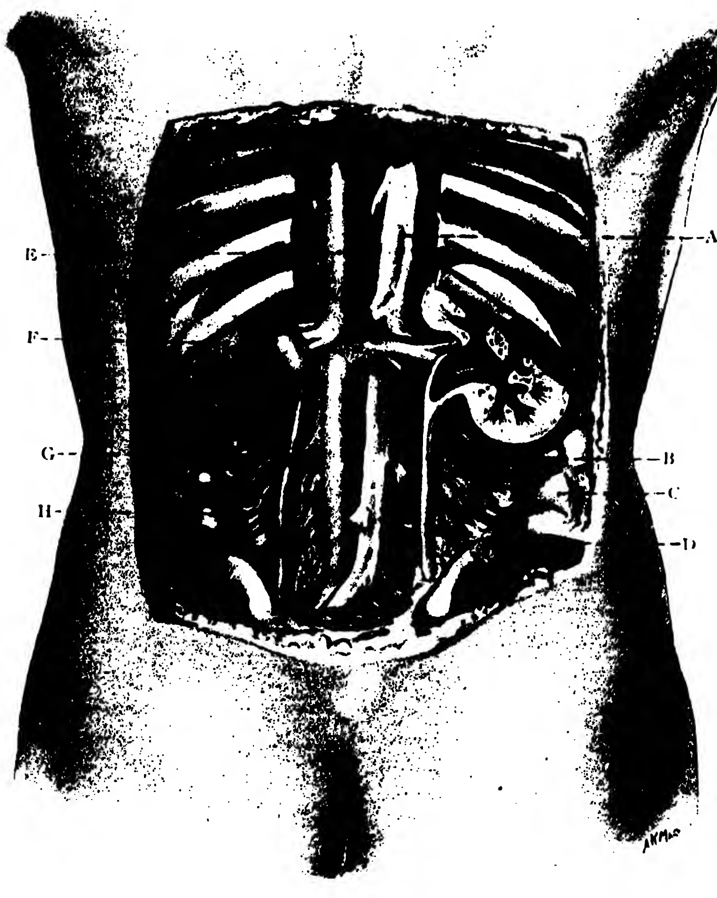


FIG. 164. THE POSTERIOR RELATIONS OF BOTH KIDNEYS. F, The left kidney entire, the pelvis of the right kidney opened, and the posterior half of the organ removed; E, the aorta, and A, the vena cava; B, the right ureter, and G, the left ureter; C, the ascending colon, and H, the descending colon; F, the left kidney in its relationship to the eleventh and twelfth ribs, and D, the crest of the ilium.

within certain limits, is of frequent occurrence, and may exist without causing any disturbance. In 1,000 post-mortem examinations, 24 cases occurred where the position of one or both kidneys might be described as abnormal.

It is also observed that in many cases the posterior surface of the kidney is placed against the crura of the diaphragm, so that during full expiration more than half the kidney lies above the level

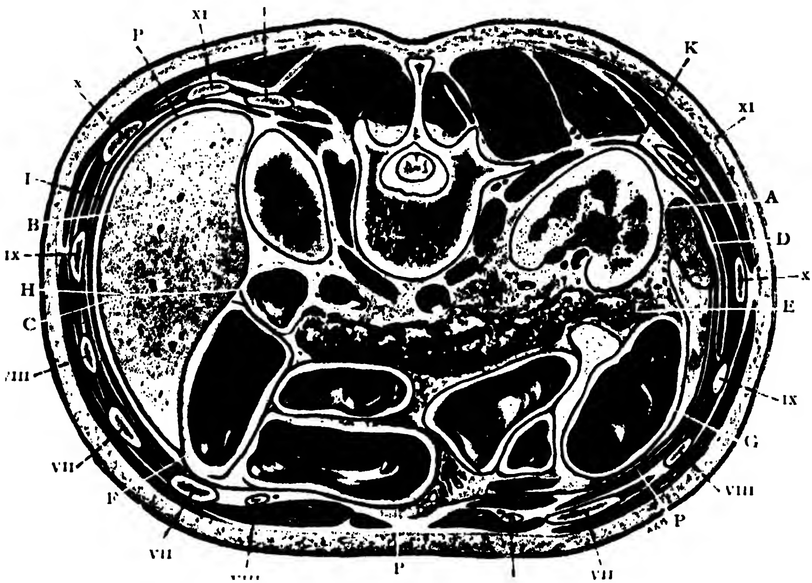


FIG. 165. HORIZONTAL SECTION OF THE ABDOMEN AT THE LEVEL OF THE FIRST LUMBAR VERTEBRA. Showing the relationship of the kidneys to other organs. A, the left kidney; K, the pleura immediately behind it; and D, the spleen on its outer side; in front are E, the tail of the pancreas, and G, the descending colon. B, the right kidney, with C, the liver, to the right of it; H, the duodenum, and F, the ascending colon, in front; behind, I, the pleura, does not come so close to the right kidney as it does to the left; P, the peritoneum. The numerals VII–XII refer to the corresponding ribs and costal cartilages.

of the lowest limits of the pleura, and during a deep inspiration the organ must necessarily be depressed through the action of the diaphragm. The lowest limit of the pleura is on a level with the lower surface of the twelfth dorsal vertebra and the lower edge of the eleventh rib, and the anterior and lower surface of the posterior segment of the diaphragm rests upon the posterior and upper surfaces of the kidney, so that during deep expiration, the kidneys being pressed up, the margin of the lung is interposed between the surface of the body and the upper part

of the kidney. This part of the lower margin of the pleura is practically a fixed line, and the degree to which the lung overlaps the kidney depends upon its position and its movements during respiration. The posterior surface of the kidney is also in close proximity to the quadratus lumborum muscle.

As a rule, the pelvis of the right kidney is situated on a level with the first lumbar vertebra or immediately in front of the lowest limit of the last rib, while the pelvis of the left kidney is about 1 inch or 1½ inches higher up. Fig. 164 shows the position of the kidneys in relation to the

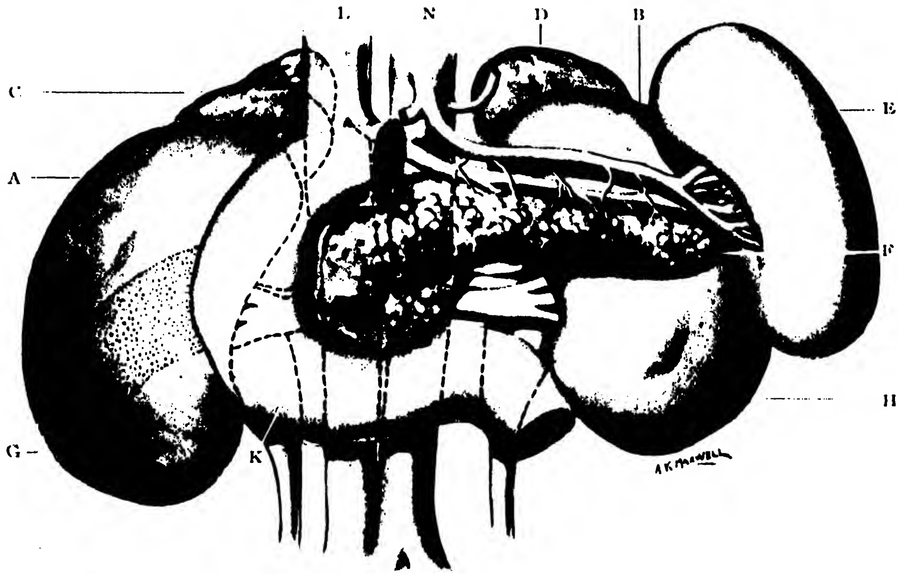


FIG. 166. THE RELATIONSHIP OF THE KIDNEYS TO OTHER ORGANS. Anterior view. A, Right kidney covered in front by K, the duodenum, and G, the colon, and above by C, the suprarenal body. B, The left kidney, covered in front by E, the spleen, by F, the tail of the pancreas, and by H, the colon; D, the suprarenal body. L, Vena cava; N, Aorta.

parts in the abdomen posterior to the peritoneum. It represents the lumbar vertebræ and the sacrum removed, exposing the posterior aspect of the peritoneum. In the middle line are shown the aorta and the vena cava, giving off the renal arteries and receiving the renal veins. Posterior to the blood-vessels the pelves are shown, that of the left kidney being only freed from its surrounding fat, while that of the right kidney has been dissected out, so as to show the branching calyces. The position is that in which the kidneys are usually found during full inspiration. Fig. 164 also shows the relative position of the ascending and descending colon, and the position of the ureters as they descend from the kidneys to

the base of the bladder. Fig. 165 represents the transverse section of the body at the level of the first lumbar vertebra: the right kidney has in front of it the duodenum, the ascending colon lies in juxtaposition to its outer margin, and the top of the kidney lies against the under surface of the liver. The left kidney touches the peritoneum just under the fundus of the stomach; in front of it, and nearer the middle line, lies the tail of the pancreas; the descending colon presses against its anterior and outer aspect, and the upper third of its external border is in close relationship to the spleen.

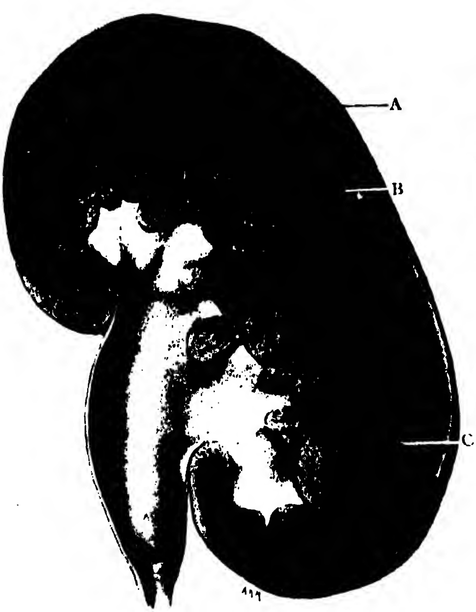


FIG. 167. VERTICAL SECTION OF THE LEFT KIDNEY. The left kidney enclosed in A, dense fibrous capsule, B, the cortex, and C, the medulla, which passing inwards becomes narrower and terminates in the papillæ; these protrude into the calyces, which have been laid open, also the pelvis.

FIG. 168. KIDNEY WITH A BIFID PELVIS. The drawing shows most of the calyces unopened and their relationship to the papillæ.

ANATOMY OF THE URETERS

The excretory duct of the kidney commences, as already described, in the calyces; these unite to form a large funnel-shaped dilatation, the pelvis, which, passing downwards and inwards from the hilum, gradually assumes a cylindrical shape, and, decreasing in lumen, reaches the level of

the lower end of the gland to form the ureter. This cylindrical membranous tube is about the diameter of a goose-quill, and from 16 to 18 inches in length. Its lumen, however, is not uniform. In normal conditions it is seen to be narrowed in three places: (1) at a point $1\frac{1}{2}$ to 2 inches below the pelvis of the kidney, (2) at the point where it crosses the iliac artery, and (3) just as it enters the wall of the bladder. The ureter is placed at the back of the abdomen, behind the peritoneum, and passes obliquely downwards and inwards and enters the cavity of the true pelvis. It then passes downwards, forwards, and inwards to its insertion into the base of the bladder. The line of the ureter is not straight; it follows several curves and may be described as sigmoid. Above the pelvis there is a slight convexity towards the middle line, while the portion within the true pelvis is strongly curved with its convexity directed outwards towards the side of the pelvis until it reaches the wall of the bladder, when the convexity becomes directed outwards and backwards.

From above downwards the ureter has the following relationships: It rests upon the psoas muscle and the genito-crural nerve, and is crossed in front by the spermatic vessels. The right ureter lies close to the outer side of the inferior vena cava, but may get in front of it, and at the brim of the pelvis it crosses the external iliac vessels; the left ureter crosses the common iliac vessels. Opposite the sacrum, the ileum is in front of the right ureter, and the sigmoid flexure of the colon in front of the left ureter; then, passing behind the fold of peritoneum forming the posterior false ligament of the bladder, the ureter runs below the obliterated hypogastric artery, the vas deferens in the male, and alongside the cervix uteri and upper part of the vagina in the female. It then traverses the wall of the bladder obliquely for a distance of about 1 inch, lying in the male about $1\frac{1}{2}$ inches behind the base of the prostate and the posterior angle of the trigone, where it opens on the inner surface of the bladder by a narrow slit-like orifice, 3 millimetres long, which has a horseshoe-shaped elevation around it, except on the inner side. The manner in which the ureter passes through the wall of the bladder, while allowing the urine to flow freely downwards, effectually prevents any reflux from below upwards.

The orifices are about 1 inch apart, when the bladder is moderately distended, and about $1\frac{1}{4}$ inches behind the neck of the bladder. The orifices of the ureters appear as little pits or holes in the mucosa and are directed obliquely forwards and inwards from the posterior angles of the trigone. They are united by a curved elevation which has a slight concavity looking forwards, and which corresponds with the muscular bands which join the ureters together; other bands extend downwards towards the neck of the bladder. Small strands of connective tissue unite the

base of the bladder to the peritoneum more firmly than to other structures, so that when exudation occurs behind the peritoneum the ureters are dragged forward, unless inflammatory adhesions have formed uniting them to the structures behind. Underlying the fibrous coat are found two layers of muscular fibres, one circular, the other longitudinal.

The lumen of the duct varies slightly along its course. It may be dilated at intervals. The narrowest part is where it passes through the wall of the bladder, and at the internal opening, which corresponds to the sphincter; indeed between the periods of evacuation of urine into the bladder the aperture is closed, and only becomes opened for a few seconds at a time, while a shoot is being forced down. The other part of the ureter where there may be slight constriction is immediately below the pelvis of the kidney. With these two exceptions, the ureter may be described as fairly uniform in calibre.

CHAPTER II

METHODS OF PHYSICAL EXAMINATION APPLICABLE TO THE KIDNEYS AND URETERS

INSPECTION

VIEWED from the front, the kidneys occupy a position within the following limits: At the level of the umbilicus draw a horizontal line, and at right angles to it draw a line from the middle of Poupart's ligament; the point of intersection will correspond to the middle of the lower pole of the kidney. Or draw a perpendicular line from the ensiform cartilage to the symphysis pubis, and at right angles to it draw a horizontal line at the umbilicus. On the horizontal line fix two points, one on the right side, and the other on the left, 4 inches from the middle line, and from these points draw upwards two perpendiculars, 4 inches long, parallel to the middle line. Unite the upper extremities of these lines by a second horizontal line. Both kidneys will be included within this quadrangular space.

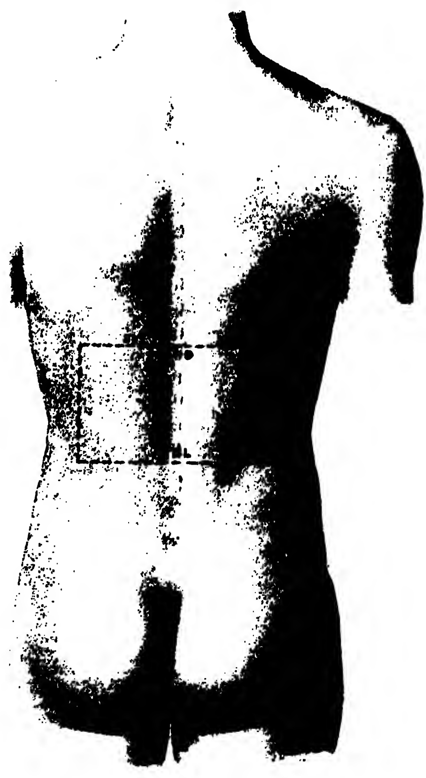


FIG. 169. POSTERIOR VIEW OF THE BODY, SHOWING THE SPACE NORMALLY OCCUPIED BY THE KIDNEYS.

On the posterior surface of the body the boundaries may be fixed as follows: Draw a horizontal line on a level with the highest point of the spinous process of the eleventh dorsal vertebra, and a second line at the lower edge of the spinous process of the third lumbar vertebra (see Fig. 169). Let these lines extend $3\frac{1}{4}$ inches to right and left of the middle

line, and join their extremities by two perpendicular lines; both kidneys will be within the space so marked.

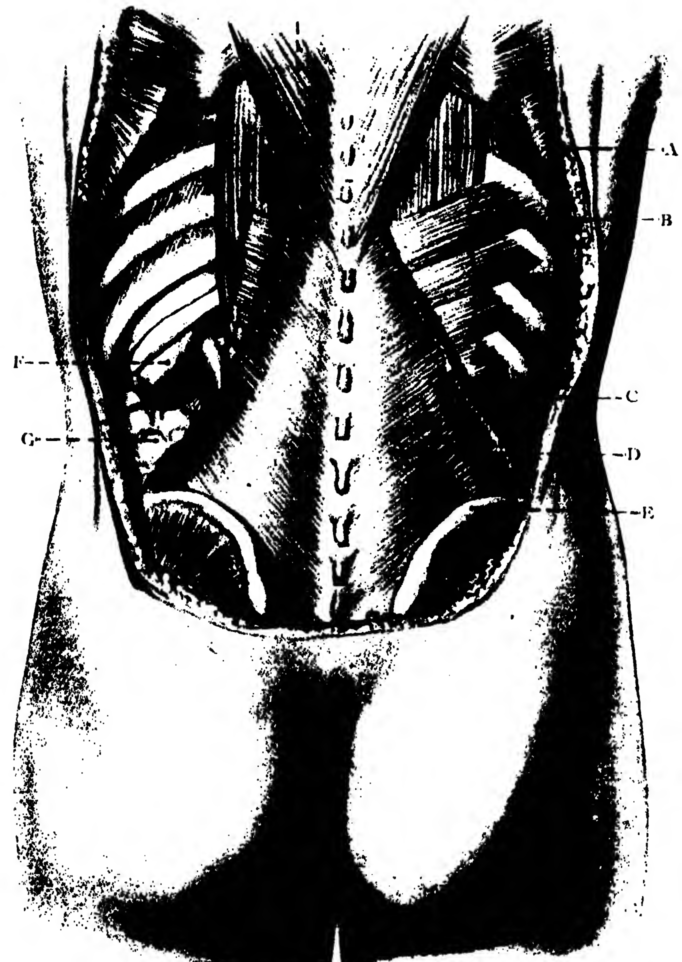


FIG. 170. POSTERIOR RELATIONS OF THE KIDNEYS. Showing the structures involved in the line of incision, the left kidney, F, being exposed and showing its relationship to the lower ribs and the descending colon, G. C, The latissimus dorsi; B, the serratus posticus, and D, the lumbar fascia; H, the trapezius, and A, the quadratus lumborum; E, the crest of the ilium.

While the measurements just given must be admitted to be only approximately correct, they are more reliable than the measurements taken from other anatomical landmarks. The kidneys being posterior

to the peritoneum, when enlargement occurs the serous membrane is pushed forwards from its posterior attachment, and the abdominal contents, being less resistant, are pressed forwards, while the firm structures behind the kidney seldom yield so as to cause more than an indistinct fullness in the loin. Therefore, while the enlarged kidney is in close contact with the posterior abdominal wall, it is separated from the anterior by the contents of the peritoneal cavity.

Inspection should be made, not only while the patient is in the recumbent position, but also from the side and from the back, and in each position it is well to make the patient assume different attitudes, *i.e.* in the elbow-knee position, or with the knees flexed in the recumbent posture. By inspecting the abdominal wall in these different positions, we may note irregularities on the surface and abnormal communication of the movements of respiration. These are specially noticeable when the kidneys are greatly enlarged or freely movable, as, for example, in cystic degeneration of the kidney, in hydronephrosis, or in movable kidney. The relationship of other organs to the kidney may also be ascertained.

PALPATION

Abdominal. Except in thin persons, with lax abdominal walls, the normal kidney in its natural position can seldom be felt by bimanual

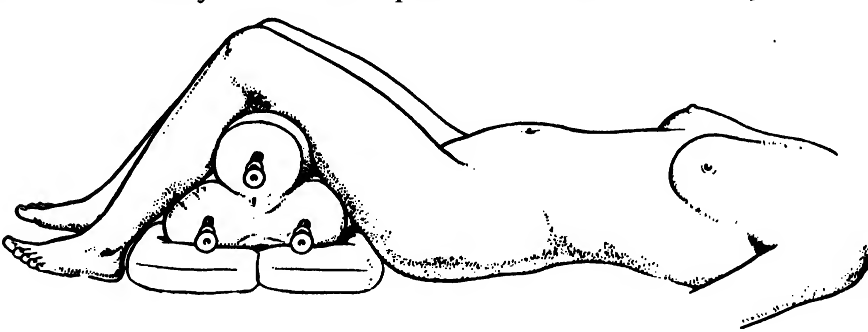


Fig. 171. The Position of the Patient best suited for Palpation of the Kidney. The knees raised and resting on pillows and air-cushions and the head and shoulders slightly raised.

palpation, and even under favourable circumstances all that can be made out with the hand is the lower border of the gland. In obese, muscular, or nervous patients even an enlarged kidney may be difficult to examine without the aid of an anæsthetic.

Palpation is most effectually carried out by placing the patient in the supine posture, with the knees drawn up and the chest slightly elevated,

so as to relax the abdominal muscles. Occasionally it is necessary to palpate with the patient lying prone, turned on one side, sitting, or standing erect. It is always well to divert the patient's attention from the examination, and to make him breathe deeply and use the voice, as by so doing the muscles of the abdomen are rendered lax. The hands of the surgeon should be warm, and, to begin with, the examination should be made with

FIG. 172. PALPATION OF THE LEFT KIDNEY. *The surgeon standing on the patient's right side.* The left hand is placed below and behind the left ribs, the right hand in front of the kidney.

the whole hand laid flat on the abdomen. With steady pressure, gradually increasing in degree, but varying from time to time, not by a sudden push with the points of the fingers, one hand should be pressed deeply into the interval between the crest of the ilium and the costal margins behind; while in front the other hand is opposed to it, so as to grasp the parts, at first gently, afterwards firmly, between the two hands.

By bimanual palpation conducted in this way, the size, form, position, and consistence of the organ can be made out, or the presence of fluctuation

ascertained. This examination should be made, first, with the patient lying on his back, afterwards lying upon his face, and if necessary in the elbow-knee position. The kidney is most easily felt during full inspiration.

In cases of stone impacted in the ureter above the brim of the pelvis, much information may be gained by palpation through the abdominal parietes, provided the walls be flaccid and the patient thin. Not infre-

FIG. 173. PALPATION OF THE LEFT KIDNEY. *The surgeon standing on the patient's left side.* The left hand is placed below and behind the left ribs, the right hand in front of the kidney.

quently the ureters can be detected as hard rounded cords when they are thickened by disease. Examination should first be made without the use of an anæsthetic, in order to ascertain the degree of muscular resistance and the amount of tenderness or pain produced by pressure; if there be much more muscular rigidity and pain over one kidney than over the other, the fact should be noted. Before examination, the bowel should be cleared out by a laxative and by enemata, to remove fæcal accumulations which may seriously interfere with the examination.

The relationship of the kidney to its surroundings is such that any increase in the bulk of the organ must show itself in a downward or forward direction. The diaphragm and the strong lumbar muscles preclude expansion upwards or backwards.

Ballottement. This is simply a refined method of palpation, and in some respects it must be admitted to be superior to bimanual palpation as generally carried out. The patient, lying upon his back, is instructed to relax the muscles of the abdomen and to breathe freely with the mouth open. The surgeon then places his hands as for bimanual palpation; the fingers of the hand in the lumbar region are pressed gently forwards, and the patient is asked to rest upon them without straining; the other hand is then used to press the anterior abdominal wall slightly backwards—enough to diminish the space separating it from the kidney, but not sufficient to allow the two to come in contact. The surgeon then gives a short, sudden jerk from behind, and as he does so the kidney, if increased in size or unduly mobile, is projected forwards and lightly touches the anterior abdominal wall—a movement readily perceived by the hand in front. In this way the observer may, with a little practice, be enabled to appreciate not only an increase in the size of the kidney, but may also make out its form and consistence; and this may be done at a time when palpation, conducted in the ordinary way, may not show much change in the bulk or the form of the gland.

The jerks given with the hand from behind must be abrupt, their suddenness must be such as to take the muscles by surprise, and also, in order to communicate the *ballottement* to the anterior hand, the pressure in the lumbar region must be sustained until the kidney has touched the anterior abdominal wall. The phenomenon is most easily got in enlarged movable kidney; but the movement of itself is not evidence that the organ is unduly mobile, as it can be developed in many cases where the attachments are normal, the kidney being enlarged only.

Rectal. This form of palpation has been employed in the diagnosis of renal lesions and in ascertaining the condition of the ureters. It is most applicable to the left kidney. The patient must be an adult with an enlarged or displaced kidney, and to conduct the examination the aid of an anæsthetic is necessary. The hand, which must not be a large one, is slowly and gradually passed into the rectum, while the other hand presses the abdominal wall in front. A bimanual examination is made, and in some instances very useful information may be obtained.

Vaginal palpation may be employed in a similar way, and is especially useful in cases of stone impacted in the lower part of the ureter.

PERCUSSION

While in most persons the healthy kidneys cannot easily be limited by percussion, at least with anything like accuracy, in lean patients a dullness corresponding with the inferior and outer border of the kidney can be mapped out, and found to extend lower during a full inspiration. The proximity of the kidneys to the liver or the spleen, their position in front of thick muscles, as well as their envelope of fat, all render percussion of the normal kidney difficult; but in the absence of one kidney, and in disease associated with enlargement, percussion is of value. In the former the atrophy of the organ, or its absence, will be indicated by a clearer note being obtained over the corresponding renal region behind. If one kidney has been removed by operation, a distinct difference may be observed in the resonance of the two sides, partly on account of compensatory hypertrophy of the remaining kidney. If the morbid process has caused enlargement or distension of the kidney, the normal resonant area of the loin will be encroached on from behind. The patient should be examined recumbent, in the ventral position, or standing erect. The renal swelling can very often be accurately limited by percussion, but in some instances—for example, in cystic kidney—a resonant note may be obtained even when the enlarged kidney is easily felt with the hand; and while it is very easy to fix a clear limit by palpation, an area of diminished resonance may gradually pass to that of complete dullness. Again, a colon distended with gas may pass over the enlarged kidney, or, on the other hand, percussion may fail to betray the presence of bowel in front of the swelling, on account of the intestinal gas having been expelled by pressure.

INSUFFLATION OF THE RECTUM

Rectal insufflation with air may not be resorted to in routine practice, but only in exceptional cases. It has been employed for the purpose of distinguishing an intra-abdominal swelling from an enlarged kidney. The patient is placed upon his back, and the dull area in the renal region is carefully mapped out and marked, the colon having been previously cleared. A long tube is then introduced into the rectum, and through it air is passed slowly until the colon is fully distended. The abdomen is then again percussed, and the change in resonance noted. If the swelling be intraperitoneal the dullness may be diminished only, whereas if it be renal a clear note can be got all over the front of the abdomen.

COMBINED VESICAL AND RECTAL OR VAGINAL EXAMINATION

Examination by the finger in the rectum or in the vagina, and with a sound in the bladder, may lead to the detection of the presence of a stone or disease in the lower portion of a ureter.

In the female, the finger can detect two cord-like bands, about 3 inches up the vagina, running backwards and outwards, and can trace them backwards for a distance of 3 inches, or even more, until they are

FIG. 174. EXAMINATION FOR A URETERAL STONE AT THE VESICAL ORIFICE.

lost behind the cervix, or follow them downwards to the base of the bladder. The examination should be made first when the bladder is well filled, afterwards when it is empty, and considerable help may be got by pressing the bladder downwards and backwards with the hand in front of the abdomen. In this way, the ureters are made more accessible and more resistant to the finger in the vagina or rectum. In health the ureters feel soft and yielding, but, as a consequence of disease, and especially in tuberculous and inflammatory lesions, they may lose their elasticity, and be converted into hard, rigid cords. Instead of exercising pressure with the hand in front, a sound may be introduced into the bladder, and its wall fixed, or the parts may be manipulated between the examining

finger and a sound introduced into the bladder. The beak of the instrument is made to press upon the line of the ureters. Exploration *per vaginam* is limited, but *per rectum* the whole of the pelvic portion of the ureters may be examined. The landmarks are the internal iliac arteries, alongside which the ureters lie.

In cases of stone impacted in the ureter, much information may be gained by palpation through the abdominal parietes when the stone is situated above the brim of the pelvis, provided the walls be flaccid and the patient thin; but when the muscles are rigid, which is often the case, or the patient is corpulent, the detection of a stone in the upper

FIG. 175. EXAMINATION FOR STONE CAUGHT IN THE URETER BEFORE IT PASSES THROUGH THE BLADDER-WALL.

part of the ureter is almost impossible. Pressure with the hand, however, generally elicits tenderness in the locality of the stone, or may even induce acute pain.

When the calculus has passed to the lower third of the ureter, examination with the finger in the rectum or the vagina, according to the sex of the patient, may lead to the detection of the stone and its exact situation. A sound should be passed into the bladder, and, with the left index-finger in the vagina or rectum, the beak of the instrument is made to press upon the line of the ureters and their orifices (see Figs. 174, 175). In the female, the urethra may be dilated and the bladder explored by the finger.

CYSTOSCOPY

The objects in view in making a cystoscopic examination in renal cases are :—

(i) To eliminate lesions of the bladder from the diagnosis.

(ii) To reveal the presence of any foreign body, calculus, plug of muco-pus, or blood-clot impacted in the mouth of the ureter.

(iii) To compare the appearance of the ureteral orifices.

(iv) To observe the size, character, and frequency of the urinary shoots from each ureter.

(v) To detect the absence of a ureteral orifice on one side, or of a flow of urine from one ureter only.

The cystoscope used by the writer was described in *The Clinical Society's Transactions*, vol. xxxix, and *British Medical Journal*, 1906.

The instrument (see Figs. 176, 177) consists of two distinct parts, a hollow stem, A, which is introduced into the bladder and retained there as long as may be required, and accessory parts which are used for cleansing the bladder or for observation. The former has at one end of the stem a cold electric lamp, B (Löwenstein's), and immediately behind the lamp is a window, C. At the other end of the stem is a pack-box, D, and a collar marked with the degrees of a circle. Passing from the pack-box at right angles is a piece of metal, E, with a slot in it, in which a movable handle, F, may be fixed. Before the cystoscope is introduced, the tube G is passed into the stem A, so that the part H acts as a shutter to the window C. After the cystoscope has entered the bladder, the tube G is rotated half a circle or slightly withdrawn, and the cystoscope is converted into a wash-out catheter. The double action stopcock, J, should then be fixed to the tube G, so as to regulate the direction of the flow of fluid. A rubber tube leading to the limb K should contain solution under the fluid pressure of a 2-feet column, while a rubber tube leading from L should contain fluid having the suction of a 2-feet fall, the former for ingress, the latter for egress of the solution from the bladder. This part of the apparatus practically affords a wash-out catheter by which the bladder is cleansed prior to the introduction of the telescope M, so that the prism N comes to be immediately opposite the window C. The electrodes are introduced into the openings O and P, the circuit is completed by pressing the switch R against the body of the cystoscope, the lamp is lighted and the observation made. Should the fluid become opaque before the examination is completed, the bladder may be rewashed by withdrawing the telescope and reintro-

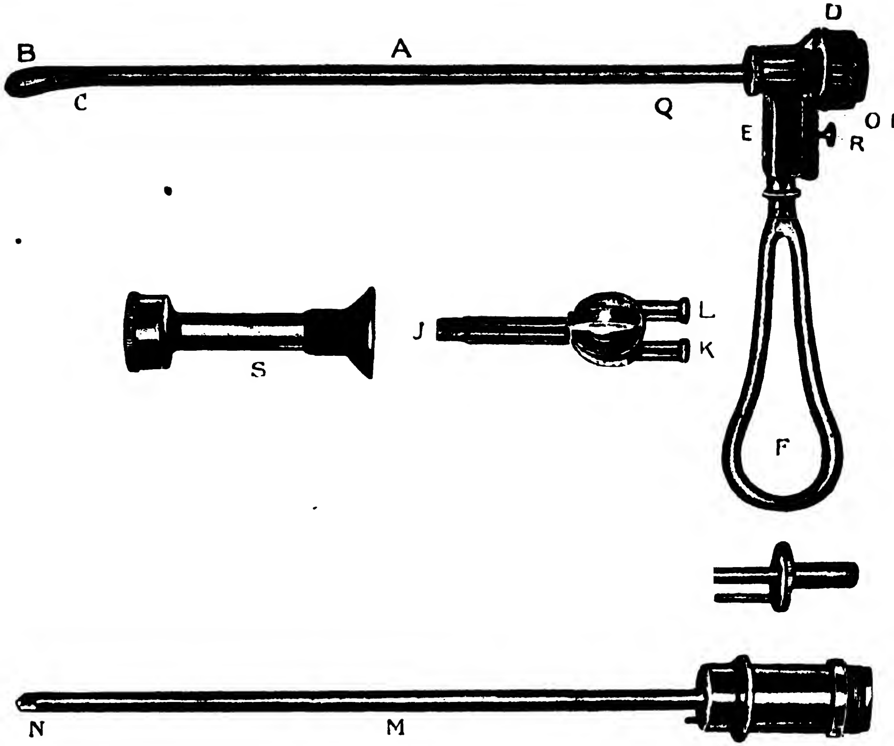


FIG. 176. AUTHOR'S CYSTOSCOPE. To the end of the hollow stem A a cold lamp, B (Löwenstein's), is fixed, and immediately behind the lamp is a window C, ¾ in. long. At the other end of the stem is a pack-box D, and passing from it at right angles a tube E, into which a movable handle F may be fixed. At D a metal drum may be fixed, divided into the degrees of a circle, and an indicator. The drum is coloured red on one semicircle, green on the other, and a jamb-screw is fitted to fix the stem in a position desired. S is the eyepiece.

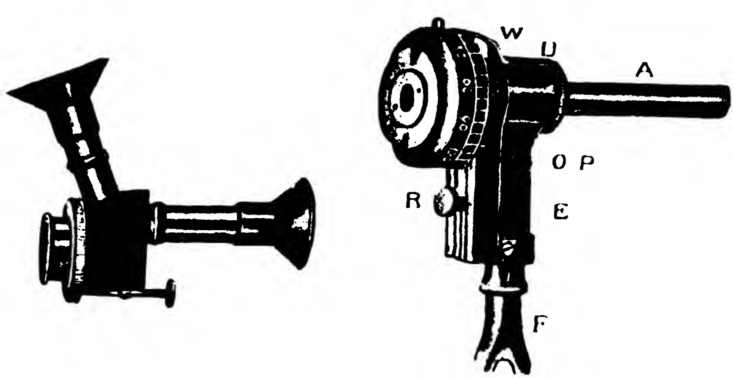


FIG. 177. DOUBLE EYEPIECE FOR AUTHOR'S CYSTOSCOPE. Two eyepieces may be screwed on to the telescope, one, the single eyepiece S, shown in the preceding figure, the other the double eyepiece figured above. In the latter the image is refracted into a second eyepiece at right angles to the shaft of the cystoscope, so that a student can look through this second eyepiece whilst his instructor is making observations through the first. The right-hand figure is an enlarged view of the drum D seen in the preceding figure.

ducing the tube G without removing the stem of the instrument from the urethra. To prevent the solution from escaping during the withdrawal of the auxiliary parts of the cystoscope there is a valve at Q.

Method of making a cystoscopic examination. In order to employ the cystoscope successfully certain conditions are necessary :—

(1) The urethra must be free from obstruction and its lumen sufficient to admit the instrument without injury to the mucous membrane.

(2) Spasm of the urethra and bladder must be controlled in order that the viscus may contain a sufficient amount of fluid, *viz.* not less than 4, and if possible 6 ounces.

(3) The fluid in the bladder must be clear for a sufficient length of time for an examination to be made.

(4) The examination should be made painless by the employment of a local anæsthetic to the urethra, but this should not be introduced into the bladder as it materially changes the appearances of the mucous membrane.

In a considerable number of cases it is necessary to cut the meatus as a preliminary step, and any stricture present must be dilated so as to allow the cystoscope to pass with ease.

The patient lies on his back with the buttocks resting a little above the edge of the table and the feet supported upon rests which can be fixed at a height suitable to the individual patient. The legs are wrapped in sterilized towels. The surgeon then takes a sheet of jaconet 18 inches square, with a small hole cut in the centre, passes the cystoscope through this opening, lubricates the instrument with glycerine, and, standing on the left of the patient, introduces the cystoscope into the bladder. At the triangular ligament a little resistance may be offered to the passage of the beak, but by gentle and steady pressure while the handle of the cystoscope is brought well down between the thighs the elbow turns the corner and the beak suddenly glides into the bladder. An assistant steadies the cystoscope by holding the handle, or by resting the loop on the end of the table. The operator, now seating himself on a low chair at the end of the table, withdraws the tube G (see Fig. 176) about $\frac{1}{4}$ inch, turns the stopcock to the right, and allows the bladder to empty itself into a receptacle constructed on the principle of a wash-out cistern. It holds 6 ounces of fluid, and as soon as filled it quickly empties itself into a bucket, so that each succeeding flow from the bladder can be clearly seen. When the fluid flowing into the receptacle becomes quite clear the height of the solution in a graduated irrigator is noted, and the quantity flowing from it into the bladder is measured, so that the examination may be made under various degrees of distension.

Suppose the bladder capable of holding without discomfort 300 cubic centimetres, the catheter tube is now withdrawn and replaced by the telescope. The observer, looking through the eyepieces, presses the switch home and completes the circuit. The prism of the cystoscope being directed towards the anterior wall when the lamp is lighted, an air-bubble, which has found its way into the viscus with the fluid, is nearly always the first object which attracts attention. If small, it appears as a shining spherule which sways with every movement of the patient or of the instrument. If large, it resembles a vibrating mirror which reflects brightly the image of the cystoscope. With the patient on his back, the air-bubble occupies the apex of the concavity of the bladder, and, marking the meridian of the sphere, it acts as a polar star, and so serves as a useful guide in locating lesions. The indicator of the cystoscope (see Fig. 177, W) is made to coincide with the position of the centre of the air-bubble. With the telescope pushed fully home the stem of the instrument is slightly rotated to the right of the observer, a systematic search is made, a general view of the bladder is obtained, and, should any abnormalities be seen, their position is noted. A general inspection having been made, special attention should be directed to the area of the trigone, as it is at the base that evidence of disease, such as ulceration, tuberculous disease, sacculation, tumours, calculi, and foreign bodies, is most likely to be found. The orifices of both ureters should be seen and their appearances carefully noted. The power of detecting them can be easily developed with a little practice, and they can usually be found in a few seconds.

Difficulties met with in cystoscopy. Stricture of the urethra, enlargement of the prostate, extreme irritability of the bladder, and hæmorrhage are the chief difficulties which we have to contend with, but with a wash-out cystoscope such as has been described above, the last-mentioned obstacle is easily overcome. In some cases of tuberculosis it is impossible to get a satisfactory view on account of the small quantity of fluid which the bladder will retain, even when the patient is under the influence of a general anæsthetic.

Prior to a cystoscopic examination, careful inquiry should be made into all the circumstances of the patient. In those suffering from serious disease, in whom the introduction of an instrument is likely to be followed by aggravation of the symptoms, cystoscopy should not be resorted to unless the patient be prepared to submit to an immediate operation, should it be deemed necessary.

The following observations have a direct bearing upon cases where important questions require to be answered definitely and clearly when operative interference is contemplated.

In a case where the evidence points to a renal lesion but neither

the symptoms nor the physical signs clearly indicate the organ involved (for example hæmaturia, from a small tumour in the kidney), the cystoscope will show the side from which the blood is escaping. When there is a doubt whether the disease is limited to the kidney or also involves the lower urinary organs (tuberculosis), the cystoscope will show the extent of the lesion in the bladder. In some cases of renal calculus the pain is referred by the patient, not to the kidney containing the stone, but to the position occupied by its healthy neighbour (renal reflex pain). When hæmaturia is present, blood will be seen escaping from the ureter corresponding to the kidney containing the calculus; when there is no bleeding, an irritable condition of the lips of the ureter will betray the site of the disease.

One kidney is known to be diseased. Is the other functionally active and fit to do double duty when called upon? By watching the character, size, and frequency of the shoots from each ureter, a very clear idea can be arrived at as to the activity of each kidney.

The majority of surgeons recognize the use of the cystoscope in its application to vesical disease, even although they may not practise its use; but few fully appreciate its value in gaining information regarding renal lesions. It should be a routine practice to make an examination of the bladder in all renal cases prior to operation, almost as regularly as an examination of the urine. By so doing many fallacies in diagnosis and errors in treatment will be avoided.

In relationship to diseases of the kidney, examination of the bladder with the cystoscope has proved of great practical value, not only in a negative way by eliminating lesions of the bladder from the diagnosis, but also by giving positive evidence of the presence of disease in one or both kidneys. When nephrectomy is contemplated on one kidney, a knowledge of the presence and functional activity of the other is of primary importance. From ocular inspection, if carefully carried out by an educated eye, exact conclusions may be drawn which cannot be arrived at by other means, and the course of treatment can be decided upon early in the course of the disease. By so employing this method, most valuable time may be utilized, which would otherwise be wasted, while waiting for other evidence to prove the nature of the renal lesion.

Cystoscopy, when conducted with aseptic precautions, is unattended with danger, and is comparatively easily carried out in both sexes, but, for obvious reasons, with greater facility in the female.

In health the urine collects slowly above the closed sphincters at the orifices of the ureters, and at intervals is thrown into the bladder by squirts with considerable force. The length of the intermissions depends upon the activity of the kidney; under favourable circum-

stances, about ten to fifteen drops are ejected alternately from each ureter every thirty or forty seconds. By watching the line of the ureter carefully, the portion coursing through the wall of the bladder, the part immediately above the sphincter, will be seen to distend gradually.

Immediately before the urinary squirt appears, the expanded duct, looking in form not unlike a miniature engorged leech, is drawn slowly upwards and outwards. It gives a sudden wriggle, its muscular fibres contract, the sphincter is forced open, and the contents are ejected. The urine forms a distinct jet which shoots downwards and inwards as it is thrown into the bladder. The spurt occupies about two seconds, and its form can be seen most easily in cases of renal hæmaturia. It is important to observe the aspect of the orifices of the ureters individually and in relation to each other. It may be stated as a general observation that when the appearance of the orifice of one ureter is altered, while that of the other is normal, the renal lesion is on the side of the morbid ureter. And, again, if the number of urinary shoots be counted within a given time, as they occur from each side, and a marked difference be observed, the side on which most shoots are seen is either the site of considerable local irritation or is functionally the more active organ. When due to morbid irritation the shoots not only succeed one another rapidly, but they are of short duration, and the urine which escapes is small in quantity; whereas in increased functional activity the shoots, in addition to being frequent, are prolonged, and the amount of the urine is large. Instead of coming in regular and distinct jets every twenty or thirty seconds, the force of the shoots may be diminished and urine may enter the bladder so slowly as to be hardly perceptible. In stricture of the ureter, or when its lumen is obstructed by a stone, the urine may dribble into the bladder, just as it dribbles out of it in cases of enlarged prostate or stricture of the urethra. In describing the orifices of the ureters we may speak of their inner and outer lips, and their upper and lower angles. In many cases the orifice of a ureter may not be visible, but it is not necessarily to be concluded that the orifice is absent or displaced; it may be merely hidden—at one examination easily seen, at another not to be found.

In some cases certain facts can be ascertained regarding surgical renal lesions by an examination with the cystoscope. For example, in many cases of renal hæmaturia, and in some of pyuria, the escape of blood or of pus from a ureter can be seen readily by the cystoscope. When the amount of blood present is small, but still sufficient to stain the urine perceptibly, the cystoscope, in the male, is more reliable than the ureteral catheter, the introduction of which into the inflamed ureter may cause a little bleeding and so vitiate the value of the observa-

tion. Pus may escape in different ways, according to its consistency; in many cases the quantity discharged from the kidneys is small, and its escape is so irregular that the cystoscope fails to establish from which kidney it flows. When, however, the diseased kidney is secreting little urine, and the quantity of pus is considerable, the discharge from the ureteral orifice may be seen readily. In some instances the pus is forced out of the ureter in form and appearance not unlike a cheese maggot, and little masses of purulent discharge may be seen on the floor of the bladder curled up like dead maggots and unmixed with the solution introduced for the cystoscopic examination; but when the bladder contracts to expel its contents, the force required to drive them out causes the purulent masses to lose their form and become intimately mixed with the fluid. In this way they are deprived of their characteristic form, which can be observed only while they are within the bladder. The disappearance of effluxes indicates that the kidney from which they should come has ceased to be functionally active. On the other hand, when the pus is seen to escape in distinct shoots, the kidney may be presumed to be still secreting a considerable quantity of urine.

From what has been said, it will be seen that many of the objects aimed at by ureteral catheterization may be attained more easily and with greater safety by the skilful use of the cystoscope.

Cystoscopic diagnosis of renal disease may be summarized in the following conclusions :—

(i) When one ureteral orifice is altered, while the other is normal, the renal lesion is on the side of the morbid ureter.

(ii) When the urinary shoots are more frequent on one side than on the other, (*a*) greater functional activity is indicated by the shoots being uniform in size and regular in rhythm; (*b*) undue irritation of the kidneys is to be inferred when the shoots, while more frequent than normal, are irregular in rhythm, unequal, and small in size; (*c*) stricture, stone, or chronic ureteritis should be suspected when the shoots are distorted in form or irregular in amount.

(iii) When the urine does not escape in distinct jets, (*a*) dilatation of the ureter without paralysis of the sphincter is indicated when the urine dribbles into the bladder at intervals, (*b*) destruction of the sphincter action is shown by the urine flowing into the bladder almost continually.

(iv) The character of the morbid fluids escaping from the ureter, or of clots, &c., occupying the opening, denotes the morbid changes taking place in the corresponding kidney.

(v) The deformity of the orifice also indicates the character of the renal disease—(*a*) pin-head contraction indicates chronic inflammation or impacted calculus; (*b*) elongation and distortion, distension of renal pelvis

PLATE III

Cystoscopic Appearances

A. The normal appearance of the neck of the bladder and of the orifice of the ureter.

B. Calculus impacted at the mouth of the right ureter.

C. Pouting lips of ureter in a case of subacute pyelitis.

D. Dilated orifice in a case of old calculous pyonephrosis.

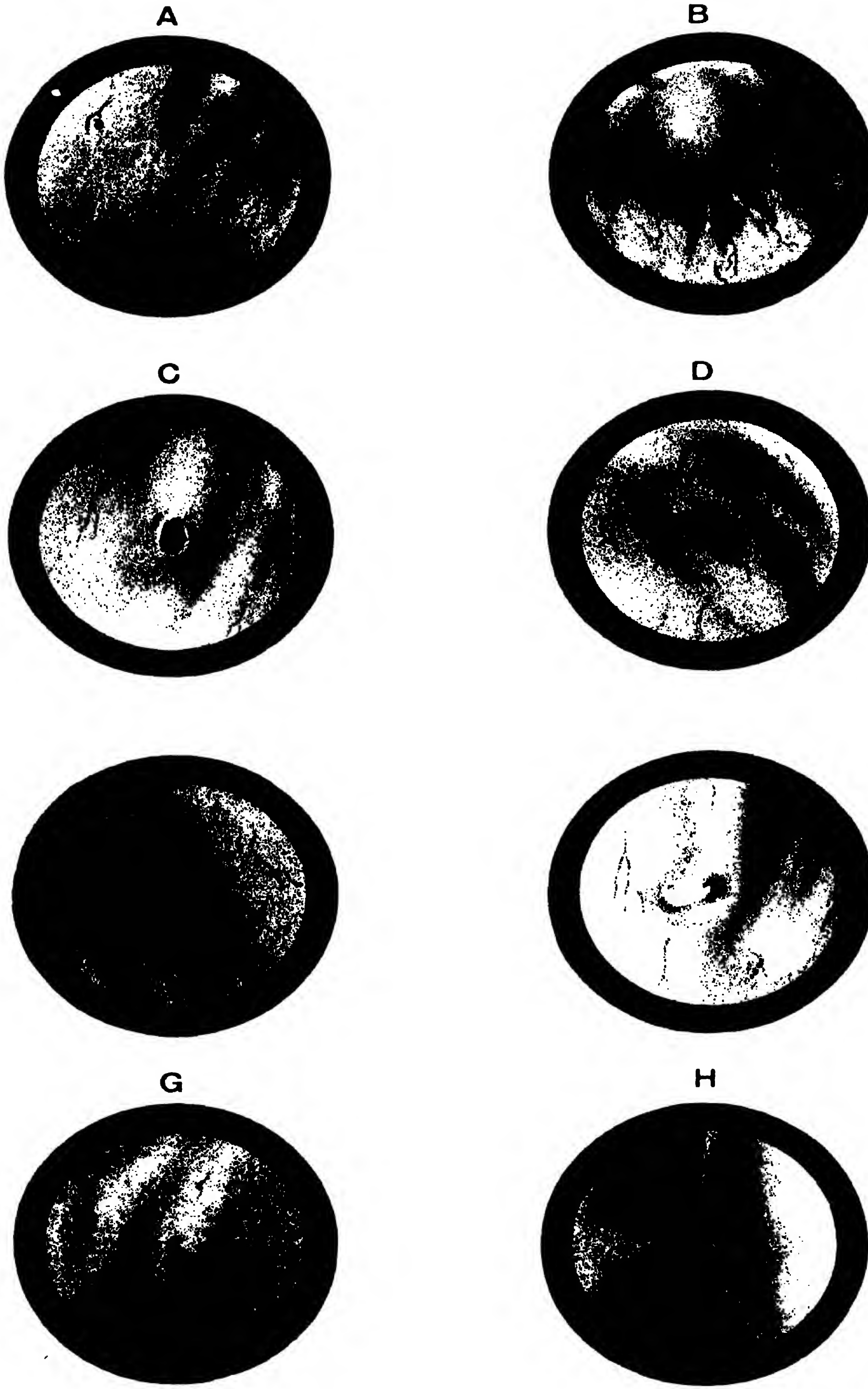
E. Marked hyperæmia at the mouth of the ureter in a case of pneumococcus infection of the kidney.

F. Appearances in a case of coli bacillus infection of the kidney.

G. Shoot of blood in a case of carcinoma of the kidney.

H. Shoot of pus in a case of acute pyelitis.

To face p. 372


A
B
C
D
G
H

or infected nephritis; (*c*) swelling or pouting, prolonged but not acute inflammation of the renal parenchyma; (*d*) dilatation, advanced tuberculous or calculous pyonephrosis; (*e*) U-shape is of doubtful significance—it usually denotes prolonged irritation of the renal pelvis.

SEGREGATION

When the presence of micro-organisms in the urine has been determined, the next point is to ascertain their source. This may be done by catheterizing the ureters or by employing urine segregators, the object being to obtain not only information as to the kidney which is diseased, but also an estimate of the functional activity of its fellow.

As the first to employ these methods of examination in this country, the writer may be permitted, after considerable experience, to express his opinion as to their value. When cystoscopy was less practised, and experience was still required to interpret the appearances revealed to the eye, the employment of segregators and ureter catheters was justified. They have not fulfilled expectations, and are clumsy and unreliable methods of trying to attain ends, many of which can now be practically reached by the cultured use of the cystoscope.

No segregator has yet been devised which fulfils the claims made upon it and placed to its credit by some of its advocates. To believe that we can construct a watertight partition in the living bladder requires considerable credulity and an unusual adaptability of natural conditions to our contrivances.

The objects in view in catheterizing the ureters are:—

1. To determine whether the disease is unilateral or bilateral by examination of the urine from each kidney.

2. To ascertain the character of the secretion from the opposite kidney when the disease is limited to one side.

3. To ascertain the presence of a second kidney before performing nephrectomy.

4. To test the patency of a ureter, to discover the presence and situation of a stricture or kink, and to localize a stone.

5. To guide the operator in tracing the course of the ureter in certain operations on the pelvic organs, and in repairing ureteral fistulæ.

Ureteral catheters are more reliable, but objections have been raised against their use on account of the alleged danger of introducing septic matter into the ureter either from the bladder or by instruments which have not been properly sterilized.

In many cases the ureter is already septic before catheterization is thought of. On the other hand, in cases of cystitis, where the kidney is

supposed to be aseptic, the catheters should not be employed unless in exceptional circumstances, as there is danger of introducing septic matter into the ureter, even although they are carefully sterilized, and the bladder is cleansed as thoroughly as possible. Any injury of the ureter by the catheter must add to this danger.

While frequent employment of the catheter is to be condemned, as it exposes the patient to certain risks, and while in many conditions the information obtained is unreliable, it has its value for diagnostic purposes; for example, in discovering the presence and situation of a stricture, or in locating a stone in the ureter, or in acting as a guide to aid the operator in tracing the course of the ureters.

It is in the detection of albumin, tube casts, and micro-organisms in the urine from one kidney alone that the ureter catheters are most valuable, and it is just at this point that the cystoscope fails us. But all information that the use of the cystoscope can give us should be procured before the catheters are employed.

While the writer fully recognizes the high value of catheterism of the ureters as an aid in diagnosis, it should not be resorted to unless other methods of inquiry have failed to elicit the required information. The cases in which the operation is justified are not very numerous.

For examinations of the ureters by catheters and sounds, the simple cystoscope of Grünfled is the most useful in the female. It has been modified, and the method of employing it has been improved by Kelly, Pawlik, and the writer, and, as now used, it is undoubtedly the most convenient instrument. But for general observation of the bladder in both sexes and for sounding or catheterizing the ureters in the male, the writer prefers the cystoscope of Caspar.

When it is desirable to catheterize the ureters, the beak of the cystoscope should be turned so as to point downwards and a careful search should be made for the ureter openings. When these have been located the ureteral catheters are protruded about ½ inch from the stem of the cystoscope, and the instrument is adjusted so as to bring the point of the catheter immediately over the mouth of the ureter. The whole instrument is then advanced until the point of the catheter is seen to be embraced between the lips of the orifice. The cystoscope is then kept steady and the catheter alone is pushed onwards so as to pass up the lumen of the ureter. First one and then the other ureter should be catheterized and the urine withdrawn from each examined separately. The writer, however, regards both catheterization of the ureters and segregation as being methods of examination seldom called for, and even when successful, unreliable in their results.

SOUNDING THE URETERS

In cases of stone impacted at the lower end of the ureter, the ureteral catheter may fail to pass, but on introducing a metal instrument which may be called a ureteral resonator, the sound of the metal coming in contact with the stone can be detected by the ear as well as by the hand of the observer. The instrument devised by the writer (see Fig. 178) consists of a probe which is fixed in a small flat handle and prolonged into a hollow

FIG. 178. URETERAL RESONATOR. A, Copper probe, plated silver; B, Flat handle; C, Copper or brass globe; D, D, India-rubber tubing 14 inches long; E, Wooden ear-tube to fit external auditory meatus.

brass globe or resonator, C. One end of an india-rubber tube is fixed to the proximal end of the resonator; to the other end is fixed a wooden ear-tube made to fit the external auditory meatus of the observer. The probe is introduced into the ureter, either from below upwards or, in the operation of nephro-lithotomy, from above downwards, and when an obstruction is met with the ear-tube is fixed in position and the instrument rotated slightly. If a calculus be present, the sound produced by the probe grating upon it is easily heard.

CHAPTER III

ASPIRATION, EXPLORATION, AND INCISION OF THE KIDNEY

The preparation of the patient prior to operation differs little from what is required in other abdominal operations, but the reader may be reminded of the following points:—

1. The day previous to the operation a careful estimate should be made of the functional activity of the kidneys by appropriate methods.

2. An aperient should be given the night before, an enema four hours before, and the rectum plugged with gauze immediately before the operation.

3. The skin of the abdomen and hips should be thoroughly cleansed by washing with soap and water, ether, and afterwards alcohol, twenty-four hours before the operation, and a gauze compress of 1 in 40 carbolic acid solution covered with gutta-percha tissue should be applied, and retained in position until the patient is on the operating table.

4. The bladder should be emptied and the genital organs cleansed.

5. The lower limbs should be clothed in thick loose woollen stockings extending up to the hips, and the chest and arms enveloped in warm bath towelling as a precaution against loss of body heat from the exposure during the operation.

6. The operating table should be low and covered with a pan 3 inches thick containing water at 100° F.; over it there should be a double blanket covered with sterilized waterproof sheeting.

7. When the patient has been anæsthetized, the carbolic acid compress should be removed and the skin in the area of the incision again washed with ether as before, and finally with a 1 in 20 carbolic acid solution.

ASPIRATION AND PUNCTURE OF THE KIDNEY

Indications. Aspiration and puncture of the kidney have been frequently employed for both diagnostic and remedial purposes in such conditions as cystic degeneration of the kidney, hydronephrosis, pyonephrosis, and hydatid disease. But while aspiration and puncture with the trochar and canula are unsatisfactory as modes of treatment, the

result derived from an examination of the fluid withdrawn from the kidney is, from a diagnostic point of view, of the highest value, and the operation is one which does not involve much danger to the patient.

In cases of hydronephrosis or pyonephrosis where the patient at the moment is too ill to stand a major operation, the withdrawal of the fluid may give temporary relief and enable him to recover sufficiently to undergo at a later date a nephrotomy or nephrectomy as may be required.

Operation. When the disease is on the right side the puncture should be made at a point 2½ inches behind a line drawn from the coracoid process of the scapula to the anterior superior spinous process of the ilium, midway between the crest of the ilium and the last rib. The needle should be directed forwards and towards the spine. If the left kidney be the seat of the disease the puncture may be made an inch higher, unless there be evidence of enlargement of the spleen.

EXPLORATION OF THE KIDNEY

Indications. Direct exploration of the kidney is justifiable under the following circumstances :—

(i) To determine the condition of the opposite kidney before a nephrectomy.

ii) In traumatic lesions of the kidney giving rise to grave symptoms.

(iii) In cases of sudden anuria, where medicinal treatment has failed.

(iv) In cases of doubtful diagnosis, especially suspected malignant tumours, tuberculous disease, or calculous disease with sepsis, or for the relief of tension due to mechanical congestion, inflammatory hyperæmia, or subcapsular extravasation of blood.

In the great majority of cases the symptoms and the physical signs are sufficiently significant to enable the surgeon to make a definite diagnosis before operating. In a few instances they are only sufficiently well marked to convince him that one kidney is diseased, but inadequate to support an exact diagnosis. In such cases an exploration should be made.

The symptoms which justify an exploratory incision are :—

1. Persistent or frequent hæmaturia or pyuria of renal origin, especially if blood or pus has been proved by a cystoscopic examination to come from one ureter only.

2. Frequent attacks of renal colic and persistent one-sided pain, associated with hæmaturia or pyuria, in which a calculus cannot be discovered impacted in the ureter.

3. In strumous subjects who suffer from frequent micturition and pain in one renal region without evidence of disease in the bladder.

Operation. The patient is made to lie on his healthy side with the leg straight, while the thigh on the affected side is bent at a right angle to the trunk and the knee flexed and well elevated on a pillow.

An air-pillow consisting of three separate compartments is placed under the opposite flank, distended so that at first the pelvis does not rest on the table. By opening the screw valves in the two lower segments of the pillow the air is allowed to escape until the pelvis just touches the table; the valves are then closed. The advantages of the air-pillow over sand-bags or other hard pillows are that it fits better into the loin, and

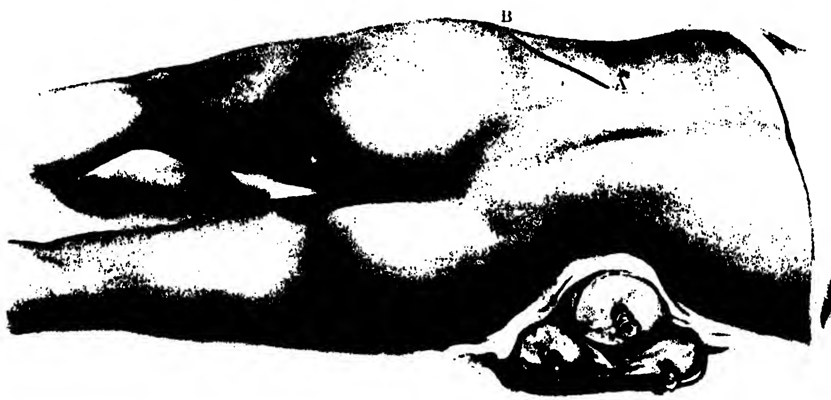


FIG. 179. POSITION OF THE PATIENT FOR EXPOSING THE KIDNEY. The + on the right-hand side is over the tip of the last rib; the other is over the centre of the crest of the ilium. The line A B is that of the incision when the space is large.

while giving the maximum of space between the crest of the ilium and the twelfth rib on the side to be operated upon, it does not strain the muscles on the healthy side as hard pillows do.

The surgeon, having defined the position of the lowest rib and the crest of the ilium, knows the space at his disposal. The ilio-costal space varies greatly, however, being sometimes 2½ to 3 inches, in other cases only a finger's breadth; hence the direction of the incision must vary according to the individual circumstances. As a rule, *when the space is small,* the incision should be similar to that adopted for Amussat's lumbar colotomy. A line is drawn from the centre of the crest of the ilium to the free extremity of the last rib, and at right angles to the centre of this an incision is made from the outer border of the erector spinæ muscles, forwards for a distance of 3 or 3½ inches, according to the size of the abscess, sac, or cyst.

When the space is large, the line of incision is from the point where

the quadratus lumborum meets the lower edge of the last rib downwards and forwards to a point on the crest of the ilium 2½ inches posterior to the anterior superior spinous process (see Figs. 179 and 180). The skin, fascia, &c., being divided, the latissimus dorsi and the edge of the external oblique muscles are seen, and should be divided in the same line as the incision through the superficial tissues (see Fig. 180). The internal oblique muscle and the fascia lumborum are thus exposed, and must be carefully divided, when the adipose capsule of the kidney is brought into view.

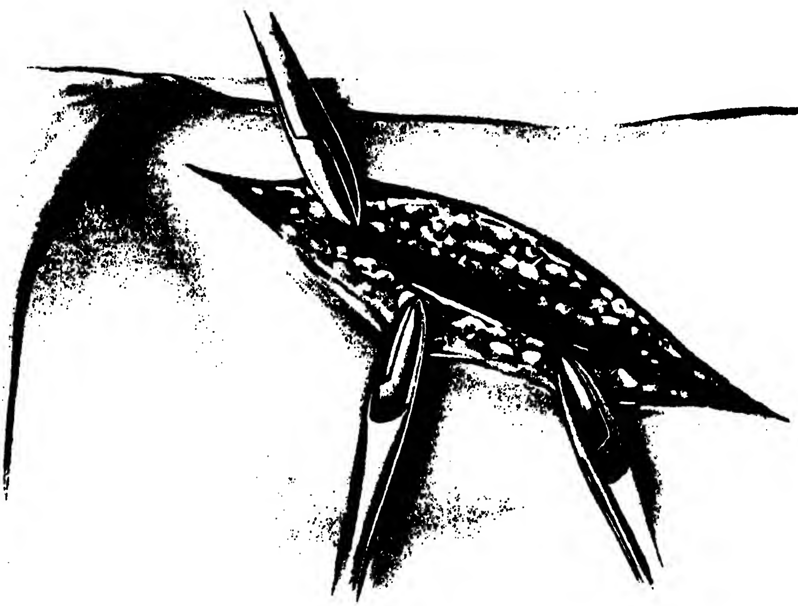


FIG. 180. SUPERFICIAL INCISION FOR EXPOSING THE LEFT KIDNEY.

A careful examination of the kidney should be made by systematic palpation, and, if necessary, by puncture. When freed from its surroundings the kidney should be drawn through the wound on to the surface of the loin. Steady traction is required, but force must be avoided. In most cases delivery of the kidney can be effected easily if the kidney be not greatly enlarged, the ilio-costal space unduly small, or the parietes unusually thick; but should the conditions prevent the organ being exposed to view, either the space must be enlarged by dividing the twelfth rib subperiosteally and freely incising the quadratus lumborum or the kidney must be examined *in situ*. Further proceedings depend upon the exact conditions found.

Difficulties. The difficulties met with in exposing the kidney are: (1) A narrow ilio-costal space; (2) a thickset trunk with fat parietes; (3) rigidity and thickening of the lumbar muscles; (4) inflammatory adhesions around the kidney, causing matting of the parts, induration of the kidney, and adhesion of the fatty capsule; (5) flatulent distension of the colon, causing the bowel to protrude backwards; (6) a high position of the kidney, the entire organ being placed above the level of the twelfth rib; (7) downward displacement of the kidney below the crest of the ilium; (8) atrophy of the kidney, the wasted organ being enclosed in a dense mass of fat.

NEPHROTOMY

Indications. (i) To relieve vascular tension arising from mechanical causes division of the fibrous capsule and incision of the parenchyma is of much value. In 1896 the writer drew attention to the fact that the albuminuria consequent upon the torsion of the renal vein in cases of movable kidney was relieved by incision of the capsule and fixing the kidney by nephropexy; and again, before the Clinical Society of London (*Clin. Soc. Trans.*, vol. xxx, p. 65), he demonstrated how dividing the capsule gave relief to severe renal pain amounting to colic resulting from mechanical congestion associated with albuminuria, hæmaturia, and in some instances with tube casts. Since that time much has been written on the question of decapsulation in chronic Bright's disease, and many rash and ill-considered opinions advanced, because of erroneous views as to the ends to be attained by incision of the capsule or of the parenchyma. If decapsulation does good in cases of chronic Bright's disease, it is probably by relieving tension and congestion, not by promoting an anastomosis between the blood-vessels of the parenchyma of the kidney and those of the surrounding structures. It must be remembered that the arteries of the kidney are 'endarteries'.

(ii) A question, however, which well deserves the attention of the surgeon is, how far incision of the capsule and parenchyma is beneficial in acute inflammatory hyperæmia of the kidney, indicated by severe renal pain, pyrexia, hæmaturia, and the presence of blood-casts in the urine, due to direct infective lesions. For example, in cases of unilateral pneumococcus infection of the kidney, marked improvement in the condition of the urine may be produced at once by the relief of tension of the swollen parenchyma; also in scarlatinal nephritis. When anuria is threatened in these cases, the activity of the kidney may often be restored by free incision of the cortex. Indeed in all acute inflammatory affections where the swelling is sufficient to induce pain and scanty excretion, it is

difficult to say how far the prolonged congestion can be endured without entailing serious degenerative changes in the renal epithelium. The fact that the kidney is enclosed in a strong limiting membrane, capable of comparatively little elasticity, renders increased vascular tension a matter of serious importance.

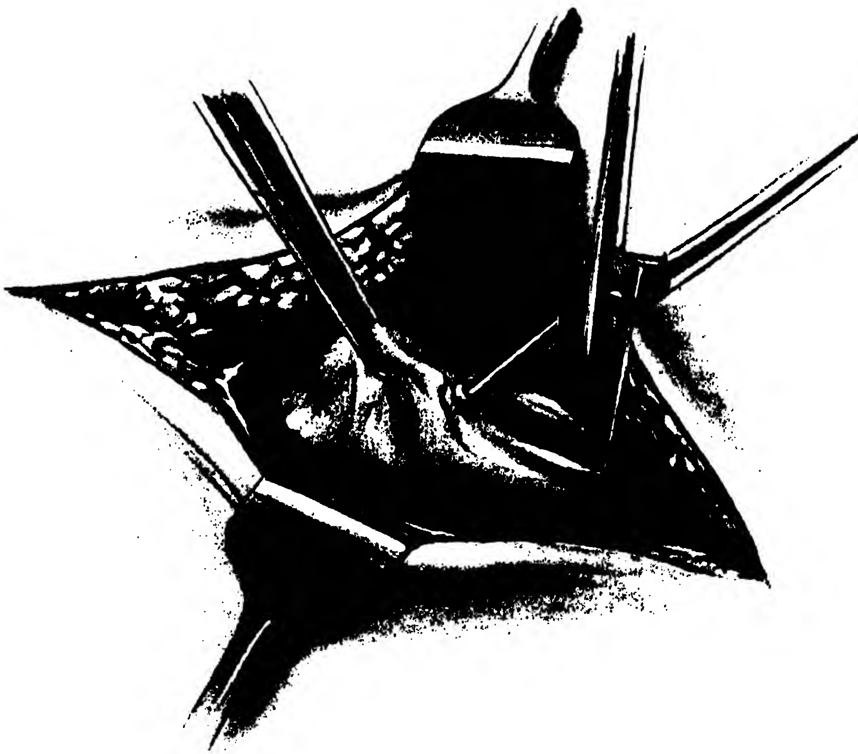


FIG. 181. DILATIN E OPENING IN THE RENAL SAC WITH DRESSING FORCEPS.

(iii) The remaining conditions which may be remedied by nephrotomy are benign tumours of the pelvis of the kidney, non-tuberculous pyelitis, calculous hydronephrosis, and pyonephrosis. The statistics of operations for benign tumours of the renal pelvis are based upon so small a number of cases that it is not possible at present to express an opinion, but if the surgeon can assure himself of the exact nature of the tumour by having a histological examination made of the growth at the time of the examination, a conservative course may prove successful.

A disease in which operation is contra-indicated is cystic degenera-

tion. Doubtless in this disease both nephrectomy and nephrotomy have been performed, but in almost all instances they have been resorted to under a mistaken idea of the nature of the case, many of the early operators having mistaken cystic degeneration of the kidney for ovarian disease. As cystic degeneration is usually bilateral and is associated with chronic interstitial nephritis, it is not a condition calling for nephrectomy, nor, seeing that the cysts are multilocular and widely distributed through-

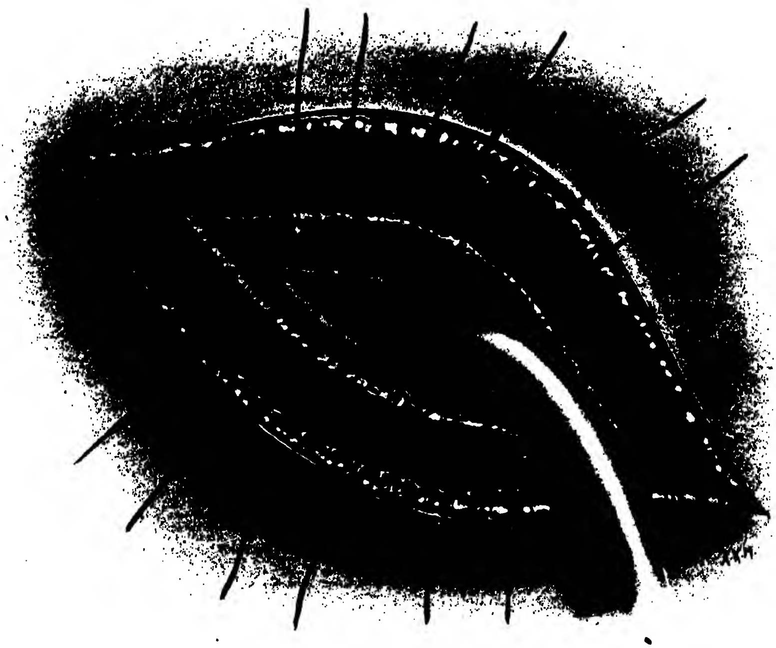


FIG. 182. THE METHOD OF SUTURING THE SAC TO THE PARIETES.

out the organ, is the patient likely to be benefited by nephrotomy; even an exploratory incision should be avoided. Any operative interference in these cases may lead to a fatal result.

Operation. The early stages of the operation are identical with those already described for exposure of the kidney (see p. 378). The kidney should always be drawn through the wound on to the surface of the loin, if possible.

When the symptoms are due to active or passive hyperæmia of the kidney, simple incision of the cortex and partial separation of the capsule may be all that is required to relieve the tension. The incision should

be made along the convex border for $3\frac{1}{2}$ inches, dividing the parenchyma $\frac{1}{4}$ inch deep.

When the morbid condition is associated with retention of fluid, fluctuation is easily made out, and palpation reveals one or two points where thinning of the cortex has taken place. The substance of the kidney is grasped with clamp forceps (Fig. 181), and a small incision is made into the cavity, which is enlarged by stretching the wound with dressing forceps until it is sufficiently large to admit the forefinger and to enable the surgeon to explore the cavity and parenchyma of the kidney.

Should the lesion prove to be a hydronephrosis, a non-tuberculous pyonephrosis, or a hyatid cyst, it is advisable not only to open the sac, but also to stitch its cut edges to the lips of the wound in the parietes, in order to reduce the danger of the surrounding tissues becoming infiltrated by urine or the contents of the sac. Two lines of sutures should be applied, one deep, the other superficial, and the parts should be adjusted as accurately as possible. The sac and the wound having been thoroughly washed out with a strong antiseptic solution, a large-sized drainage tube should be introduced at the most dependent part of the wound (see Fig. 182). The length of time that the tube must be retained depends upon the individual case.

What the next procedure should be depends upon the nature of the lesion, and the following questions require consideration :—

1. What is the general condition of the patient ?
2. Is the lesion one that can be remedied or removed by nephrotomy ?
3. If so, should it be dealt with at the time, or by a subsequent operation ?
4. Is the kidney so destroyed that it is functionally useless, and only a source of trouble and danger to the patient; and, if so, is it safer to excise the kidney now or at a later date ?
5. Is the lesion one which from its nature is inconsistent with life if allowed to remain, and should the disease be removed at once ?

The general condition of the patient should be first considered. If there be tuberculous or septic infection of the pelvis associated with serious constitutional disturbance as a consequence of long suppuration, it is well to wait, and in the meantime to be satisfied with free drainage. But if the general health be good the further steps of the operation will depend upon the local condition. The obstruction, if it be kinking of the ureter in movable kidney, may be rectified by nephropexy; if caused by an impacted stone, by its removal the natural passage will be free; if as a consequence of stricture of the ureter, ureterotomy or a plastic operation may remedy matters; but if the obstruction cannot be removed, then

the surgeon should satisfy himself by establishing a drain in the loin and a subsequent nephrectomy be left for further consideration. This rule should apply both in cases of hydronephrosis and pyonephrosis. To remove the kidney when the sac is large, and the patient is still suffering from the effects of an acute, often a critical illness, is a mistake. The danger to life is considerable and the healthy kidney may fail to respond to the additional work placed upon it.

When the cortex is cut into, sharp but not prolonged hæmorrhage occurs and can usually be easily controlled by pressure, or by retaining the finger in the wound for a few minutes. By making the incision in the line of the vessels and uriniferous tubules, few arteries of any size are divided, and the smaller arterioles, which bleed profusely at first, soon contract and become closed. For statistics of the operation see p. 403.

Difficulties. When the kidney is not greatly altered in appearance, the operation of nephrotomy is easily performed, but in not a few instances the structural changes in and around the organ are so great that it is with the utmost difficulty that the surgeon can assure himself of the relationship of parts. This arises from induration and hypertrophy of the adipose capsule, which becomes tough and inseparable from the kidney, or the organ may be distorted or shrunken, or its contents may have escaped into the perinephric tissues. Under such circumstances the incision must be made at the most prominent point.

The dressings and after-treatment will be considered in the following chapter (see p. 389).

CHAPTER IV

NEPHRO-LITHOTOMY

Indications. When the kidney or its pelvis is occupied by a stone, it may be necessary to cut down upon the organ and remove

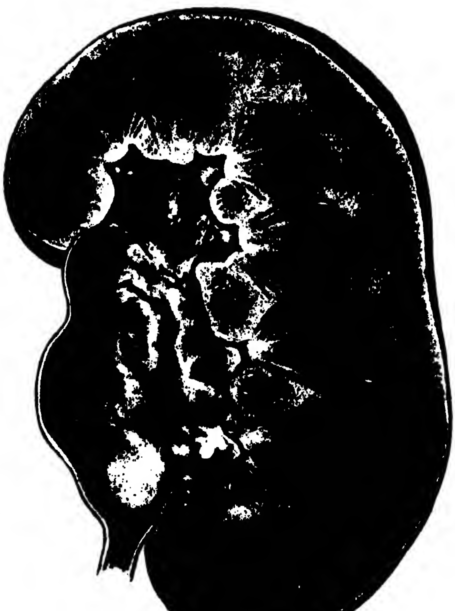


FIG. 183. A CALCULUS MOULDED AND FIXED, CAUSING NO PAIN OR HÆMATURIA, ONLY PYURIA.

FIG. 184. LARGE SHARP STONE IN THE PELVIS OF THE KIDNEY, CAUSING SEVERE PAIN AND PROFUSE HÆMATURIA. (See *Lancet*, 1909, vol. i, p. 8.)

the calculus; in other words, to perform nephro-lithotomy. In many cases a stone may be known to occupy the kidney, but may cause the patient little trouble. This depends upon the character of the calculus, and whether it is fixed in its position, or by its mobility causes obstruction to the escape of urine, or from its irregular surface irritates the mucous membrane of the pelvis (see Figs. 183, 184). This operation

may be demanded under two very different circumstances—firstly, when the foreign body has, by its presence, induced suppuration in the kidney or its pelvis; and, secondly, when, by the recent improvements in diagnosis, the surgeon is able to detect the presence of a stone before pus accumulates in the kidney or appears in the urine.

The operation may be performed either by the lumbar or the abdominal route.

LUMBAR NEPHRO-LITHOTOMY

The early stages of the operation are similar to those of exposure of the kidney (see p. 378). The later stages vary according as sepsis is present in, or absent from, the pelvis of the kidney.

When there is septic pyelitis. When the sac of a pyonephrosis is opened, a systematic method should be employed to explore the cavity of the kidney for a calculus, and for this purpose the organ should be delivered on to the surface of the loin when possible, and the pelvis and calyces as well as the parenchyma carefully examined with the fingers, which are more reliable than any other instrument in discovering a stone.

In the great majority of instances the calculus is found without trouble, but when the cavity is very large the fingers may fail to reach the deeper parts, and this is especially the case when the stone is embedded in the upper part of the ureter. In such instances it is well to drain the kidney for a few weeks and to make another search when the pyonephrosis has contracted.

The stone having been discovered with the finger, an attempt should be made to remove it through the incision already made in the parenchyma, either by the finger, a small lithotomy scoop, or forceps (see Fig. 202). Should, however, the stone be firmly fixed in the calyces, the best plan to adopt is to press the stone firmly towards the point where the cortex is thinnest with the finger in the cavity of the pelvis, and to remove the calculus entire through a fresh incision made there. This should be done, even if it demand a very free incision in the cortex, rather than break the stone, as fragments are liable to be left behind and form centres for future concretions.

Phosphatic stones, with bacillus coli infection of the renal pelvis, are often so friable that they crumble in fragments as soon as they are grasped with forceps. In such circumstances the concretion must be removed with a spoon and the whole interior of the sac scraped carefully and drained for a considerable time.

After a stone has been removed from the pelvis of the kidney, or from the substance of the organ, a careful examination must be made

to see that no other concretions exist in either of these situations or in the ureter (see p. 416). Under exceptional circumstances, when the calculus is branched and is firmly adherent, it may be necessary to divide it into two or more parts and remove each fragment separately. This is best done with small bone-cutting forceps. If no stone be found after free incision and thorough exploration, the ureter must be examined throughout its length (see p. 410).

When there is no septic pyelitis. In cases of calculus unassociated with distension of the pelvis or enlargement of the organ more difficulty is experienced in discovering the position of the stone, especially if it be small in size and embedded in the substance of the kidney. When the kidney has been exposed, the first duty of the surgeon is to examine it carefully and systematically by palpation, and should any part of the kidney or pelvis offer undue resistance, such as to suggest the locality of the calculus, this evidence must be further tested by puncturing the organ with a fine-pointed bistoury. This method of exploration must be carried through systematically and freely, there being reason to believe that the renal parenchyma suffers little from this mode of examination. The substance of the kidney having been carefully searched and no calculus found, the pelvis should next be punctured, and a curved probe or director should be passed and the entire cavity of the kidney explored.

If a calculus be detected by the hand or the probe, the operator must next consider what is the best way to remove it, and he has the choice of incising the renal parenchyma or the wall of the pelvis. If the calculus be lying close to the capsule of the kidney it is clear that the easiest and safest method of reaching the stone is by cutting through the tissue covering it, and this should be done by a straight incision with a narrow knife to begin with; the opening may be enlarged by dilating with dressing forceps, by which the stone may be seized and extracted. When, however, the stone is situated in the pelvis or one of the calyces, the question arises, Should the wall of the pelvis or the renal tissue be incised? In respect to this point there is a difference of opinion. Stones of large size have been removed by incision into the pelvis, while calculi of equal size and weight have been extracted by dividing the renal tissue by the knife. The bulk of the stone cannot therefore be taken as a guide. While the two methods are equally satisfactory in respect to the immediate result, the wound has healed more easily in those cases in which the incision has been made through the parenchyma, and permanent urinary fistulæ have been less frequent.

After the stone has been removed, the kidney should be packed with a narrow strip of iodoform gauze, or a drainage tube should be left in.

It is well not to suture the kidney, as free drainage for a few days after the operation is of the first importance, but the parietal wound, muscles, fascia, and skin must be carefully brought together, an opening being left for drainage only.

Difficulties. Besides those mentioned under nephrotomy, the presence of a stone in the kidney presents difficulties peculiar to that disease. (1) The stone may be so small that it is very difficult to locate it in a calyx, or in the pelvis (see Fig. 185), or it may occupy an independent pouch and only drop into the pelvis occasionally. (2) The calculus may be branched and firmly adherent to the calyces or pelvis. (3) Very large stones are often difficult to remove, or considerable trouble may be required to remove all the calculi present because of their large number. (4) The stone of phosphatic origin may break up very easily, and consequently can only be removed in fragments. (5) A calculus of considerable size may exist in the kidney without being detected, even by a most careful and skilled examination. Morris mentions a case in which he removed 'a healthy kidney for a calculus, the size of a marble, embedded in it, but which I could not localize. Even after the removal of the kidney, the locality of the stone could not be made out by pressing the organ between the finger and thumb, nor by pressing upon the kidney as it lay upon the table'; and in connexion with this case he remarks: 'The kidney becomes very hard and tough under the prolonged irritation of a stone, so that whilst the whole organ feels firmer than natural, any slight difference in the degree of resistance of one part is all the more difficult to appreciate. This hardness of the renal substance should make the surgeon very suspicious of a calculus,

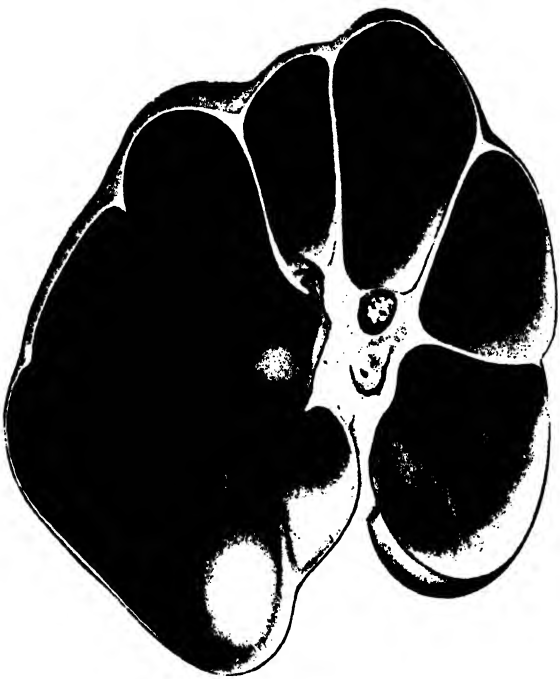


FIG. 185. A SMALL STONE CAUSING COMPLETE DESTRUCTION OF THE KIDNEY AND VERY LARGE HYDRONEPHROSIS.

and future experience will, I think, encourage him, when this condition is present, not to be satisfied either that no stone exists or that nephrectomy must be performed, until he has made such an incision into the kidney as will open each of the calyces. Kidney wounds are known to heal readily, and whilst the risk of such an incision would not equal that of nephrectomy, the subsequent condition of the kidney would be preferable to the possession of only one organ.'

Dangers. *Hæmorrhage.* While the loss of blood at the operation may be considerable, it is not often a serious danger except in patients whose strength is greatly reduced, and any considerable loss of blood following the operation is rare. The cases in which bleeding is most difficult to control are those in which we have to deal with tissues which are indurated, and when the arterioles are converted into rigid tubes which do not contract or retract when divided. In such cases it is safer to excise the kidney. If the bleeding cannot be controlled at the operation by douching with hot water, plugging with gauze, and applying pressure to the surface of the kidney, adrenalin may be employed locally. Should these methods not succeed it will be necessary to remove the kidney.

Shock. In old-standing disease shock is often very marked for the first eighteen or twenty-four hours, and sickness may be persistent. This should be guarded against by having the patient under observation and treatment for some time prior to the operation, so as to get him into as favourable a condition as possible. Also the surgeon should be specially careful to operate as rapidly as possible, and not to do more than is absolutely necessary at the time. Loss of body heat may be avoided by wrapping the limbs and as much of the trunk as possible in warmed gamgee tissue, and, if necessary, strychnine and saline injections may be administered.

Septic infection. This is only likely to happen when the surgeon fails to provide free drainage. If the drain be kept in till the surfaces of the wound have had time to granulate, the pyonephrosis is not likely to cause any general infection.

Uræmia. This is only likely to occur when the other kidney is also diseased, but, with our present methods of examination, this emergency should be foreseen and guarded against.

After-treatment. The patient should be placed in bed in the recumbent posture with a soft pillow under the shoulder and hip on the affected side so as to avoid pressure on the wound. The dressings should be changed at frequent intervals if any blood or urine soaks through.

The packing or drainage tube may be removed or shortened on the fourth or fifth day in a non-suppurative case, but when sepsis exists prior to the operation, a tube should be retained as long as a purulent dis-

charge continues. In such cases the wound should be douched with 1–40 carbolic acid solution.

When there is much shock after the operation, the foot of the bed should be raised on blocks, hot bags applied, and rectal feeding employed until nourishment can be taken by the mouth. Warm barley-water, flavoured with lemon, and warm soured milk are most easily retained, and are very grateful to the patient, and while they act as diuretics they also prevent flatulence, which is often so troublesome after renal operations.

When suppression of urine occurs, normal saline injections into the rectum or into the subcutaneous tissue are indicated, or subcutaneous injections of pilocarpin may be administered.

Retention of urine after renal operations is very common and requires the passage of a catheter. In men, the reflex congestion of the mucous membrane of the urethra and the muscular spasm are sometimes so great that a catheter will not pass—even the gentle introduction of an instrument may cause free bleeding. Rather than persevere with the catheter it is advisable to apply hot fomentations to the perineal and hypogastric regions, and to introduce a half-grain or a grain morphia suppository.

Results. The causes of death in nephro-lithotomy depend not upon the operation but upon the stage of the disease for which it is performed. Eliminating all cases in which the presence of a calculus was associated with sepsis, nephro-lithotomy may be described as almost free from danger, the mortality being only 1·8%, whereas when sepsis has been established a very different result (8·7%) is obtained (see p. 403).

ABDOMINAL NEPHRO-LITHOTOMY

Abdominal nephro-lithotomy was suggested by Mr. Knowsley Thornton, who recommended an abdominal incision for the purpose of exploration, and, if a stone be found, a second incision in the loin for its extraction. Mr. Thornton practised the method here suggested; the abdominal incision admitted the left hand of the operator, who, having examined the kidneys, found a calculus in the right one. The left hand was further used to fix the stone in the pelvis of the kidney, while with a knife in the right hand a clean incision was made in the loin right down on the stone.

The arguments brought forward in favour of Thornton's operation are—(1) That in operating by the lumbar incision alone, not only is an exact diagnosis difficult, but a stone may exist in the kidney without being detected, or the surgeon may even fail to reach the kidney;

whereas, by the combined operation we should 'never fail to find the kidney, never cut into a healthy kidney, and leave the one with the stone; never damage the peritoneum by a puncture without knowing it, and we could examine the other kidney and both ureters. . . . The stone would be removed through a small clean cut in the loin, which was far preferable to the method of dissection, since this latter allowed of infiltration of the tissues, and favoured the chances of severe inflammation and septicity; and, finally, the combined method allowed of a thorough examination of the kidney, so that a decision could be come to which was the best operation—nephrotomy or nephrectomy—for the individual case.'

In opposition to these arguments of Mr. Thornton's in favour of the combined operation, it has been pointed out by Mr. Godlee 'that while a number of stones might be cleared out of a kidney which were causing no symptoms, a small one might escape the detection even of the experienced in the opposite kidney, which after all had been the cause of the colic'. This argument seems to apply just as much to the lumbar operation alone as to the combined one, but let us admit the force of Mr. Godlee's words when he further proceeds to say, 'It is surely possible that, if a stone can escape detection through a lumbar incision, when the organ can be felt above and below, and behind as well as in front, it might fail to be detected when the finger can only reach the anterior aspect.' Further, it should be remembered that in many cases the amount of adipose tissue around the kidney is so considerable that, unless the stone were of considerable size, it would be impossible to detect it without cutting through the peritoneum and removing the adipose capsule from the surface of the kidney. Mr. Thornton's contention that it is impossible to overlook the presence of a renal calculus by the combined method does not hold good in many cases.

By employing the abdominal incision, the risk to the patient is undoubtedly increased. When first introduced this operation was employed occasionally, but time and experience have limited its use to only exceptional cases. The technique of the method will be described in connexion with nephrectomy (see p. 398).

CHAPTER V

NEPHRECTOMY

Indications. (i) *Tuberculous disease.* When the disease is limited to one kidney, as it usually is in the beginning, primary nephrectomy is the operation to adopt, and it may be undertaken with a very fair prospect of a favourable result. But if the disease has reached an advanced stage, as shown by enlargement of the kidney, profuse pyuria, and general aggravation of the symptoms, probably a nephrotomy will be found more suitable in the first instance, and the question of a secondary nephrectomy may be left to be determined by the demands of the individual cases.

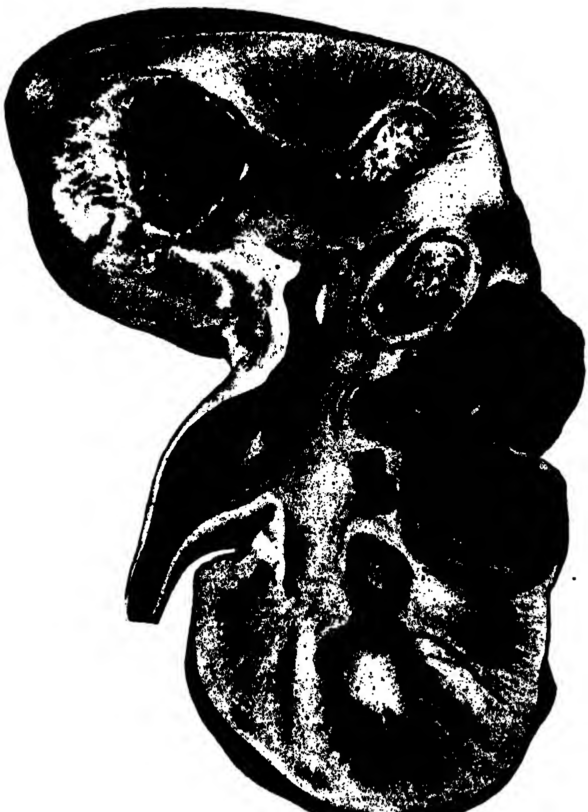


FIG. 186. ADVANCED TUBERCULOSIS OF THE KIDNEY.

When examining the urinary débris for tubercle bacilli, it is necessary in most cases to prepare at least half a dozen specimens. From the urine the micro-organisms are not easily cultivated, as putrefactive bacteria contaminate the culture and destroy the specific bacilli. Koch, however, states that he has succeeded in cultivating tubercle bacilli from cases of tuberculous pyelitis. In some instance the bacilli in the urine are so few in number that it is difficult, or almost impossible,

to discover them simply by the microscope. In such instances inoculation experiments help greatly to clear up the diagnosis (see Fig. 187).

(ii) *Malignant disease.* There are two forms of malignant disease which call for attention—sarcoma, which may be regarded as essentially a disease of early childhood, and carcinoma, which is met with most frequently in the declining years of life. In *sarcoma*, so long as there is no evidence of secondary formations and the general strength of the child gives hope of success, an abdominal exploration should be made as early as possible, and if the growth can be enucleated a primary nephrectomy should be performed. In most cases of sarcoma the disease spreads with great rapidity, and little time is afforded for delay.

FIG. 187. THE ABDOMINAL CONTENTS OF A GUINEA-PIG KILLED FOUR WEEKS AFTER INOCULATION WITH URINE FROM A CASE OF TUBERCULOUS NEPHRITIS. Showing miliary tubercles in the spleen, liver, peritoneum, omentum, and lungs.

On the other hand, in *carcinoma* of the parenchyma, but in subcapsular growths especially, the disease remains localized for a considerable period. In subcapsular growths the only signs of disease are pain and increase in the size of the kidney. By taking advantage of this circumstance the surgeon may in the future hope to celebrate a triumph, but only with the aid of the general practitioner. Again, it is a question of early diagnosis. The great difficulty one has to contend with is that subcapsular carcinoma may be present for a long time without giving rise to a palpable swelling in the loin, pain, or other indication of its presence.

(iii) *Injury.* When the symptoms indicate that the laceration of the kidney is severe, and there is danger of the patient bleeding to death, either from the escape of blood by the ureter or into the tissue surrounding the kidney, the surgeon is justified in cutting down upon the kidney and removing it if the organ be destroyed.

It is obvious that when there is evidence of effusion of blood or of urine into the peritoneal cavity, immediate abdominal nephrectomy is indicated, and during the performance of the operation the kidney and spleen should be explored and any lacerations attended to; but when rupture of the kidney alone is suspected, and the hæmorrhage is not severe, it is well to delay interfering, so long as urine is freely excreted, as in a large proportion of cases palliative treatment is all that is required. Nephrectomy may be partial or complete, and the kidney may be excised either through a lumbar or an abdominal incision.

(iv) *Septic infection with or without calculus.*

The arguments for and against the median and lateral abdominal and the lumbar methods of performing nephrectomy may be stated thus:—

The first method has been largely employed in the treatment of such conditions as hydronephrosis, cystic disease, and neoplasm—lesions in which considerable space is required for manipulation. In so far as it widens the field of operation, and gives the operator free access not only for the removal of the diseased parts and for the controlling of hæmorrhage, but also for the purpose of ascertaining, as far as is possible by palpation, the condition of the other kidney, this operation is to be commended. But while these advantages cannot be denied, it has been urged against both of the abdominal operations, but especially the median, that not only is the peritoneum wounded, but the mesocolon must be divided before the kidney is reached. Besides, as a consequence of the situation of the wounds and the circumstance that the peritoneal cavity has been opened, it is found difficult to drain away the blood and discharges without contaminating the abdominal sacs, and thereby increasing the danger of death from peritonitis.

Another, but what seems to be an unlikely drawback to the abdominal operations, is the supposed liability to ventral hernia at the site of the incision through a tense muscular abdominal wall. Taking all cases of abdominal section, in how many has ventral hernia been induced? Very few have been published, notwithstanding the large number of abdominal sections that are being performed yearly. The two most serious objections to the abdominal operations are the trouble occasioned during the operation by the intestine protruding through the wound, and the difficulty in procuring efficient drainage afterwards.

The advantage claimed for the lateral abdominal (Langenbuch's) incision, as compared with the median abdominal, is that by careful manipulation, even although the peritoneum be opened during the first stage of the operation, the kidney can be removed without danger of the cavity of the abdomen being contaminated by subsequently suturing the mesocolon to the margin of the anterior lip of the parietal incision.

Another reason why this operation should be selected is that, on account of the situation of the incision at the outer border of the rectus muscle, the kidney is easily reached and its vessels and ureter secured, while at the same time the large veins in the anterior layer of the meso-colon are avoided. By this operation good drainage is secured, and the wound is practically made an extra-peritoneal one.

The advantages of lumbar nephrectomy over the abdominal operations are that, unless by misadventure, the peritoneal cavity is not opened, the wound is easily and efficiently drained, and no structures are injured except those composing the parietal wall. But, on the other hand, on account of the small space afforded, the surgeon may experience difficulty in reaching and removing the kidney in some cases, and, as a consequence of awkward manipulation, the vessels of the pedicle have been lacerated and even the renal tissue ruptured.

LUMBAR NEPHRECTOMY

Lumbar nephrectomy in its preliminary stages, that is to say,

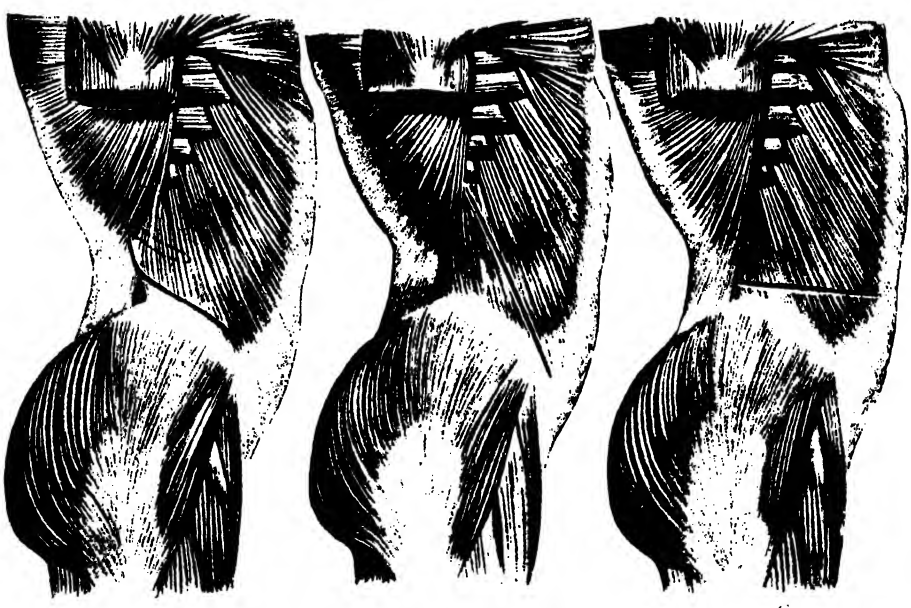


FIG. 188. INCISIONS FOR LUMBAR NEPHRECTOMY. A, König's; B, von Bergmann's; C, Péan's.

the kidney is exposed, is in most cases the same as lumbar nephrotomy (see p. 378); but, on account of the small opening thus afforded, it may

be found necessary to modify the incision. Hence, it has been recommended to make a vertical incision from the lowest rib to the crest of the ilium, and if more room be required, another cut is made in the parietes to join this one either at its upper or lower limit. These second incisions may be made in one of two ways—firstly, beginning at the upper limit of the vertical wound, by making a cut parallel to the last rib and extending it downwards and forwards; or, secondly, the incision may be made from the lowest point of the vertical wound, and extended forwards at right angles to it and parallel to the iliac crest. In making these or other incisions which may be suggested in the course of the operation, care must be taken not to go too near to the twelfth rib, as the diaphragm sometimes extends downwards from it, and the pleura may be injured by free incision in this direction.

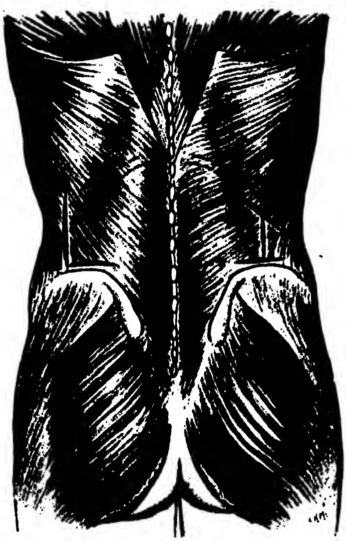


Fig. 189. Bardenheuer's Incisions for Lumbar Nephrectomy.

After the kidney has been laid bare, the next step in the operation is to separate it from its surroundings, which is easy or difficult according as the surface of the kidney has or has not formed adhesions to the neighbouring parts. When the surface of the kidney is normal, the organ can be separated from the tissues around it with ease, either by the finger or by a periosteal elevator. This is frequently the case in such lesions as hydronephrosis, cystic disease, benign tumours, and renal calculus. But when the disease is of an inflammatory nature, or has led to perinephritis, the condition of matters is very different, and the difficulties of the operation are greatly enhanced by the adhesions which the indurated adipose capsule has formed with its surroundings. Consequently in such lesions as suppurative disease of the kidney, old-standing renal calculus, tuberculosis, and malignant growths, the operation is a more serious one in itself.

While, however, the adipose and fibrous capsules have become firmly adherent to their surroundings, the kidney itself may not be so strongly united to its capsule. Taking advantage of this circumstance, it is advisable that, instead of removing the kidney in its capsule, the kidney should be exposed, the fibrous capsule divided, and the organ enucleated from it. In doing this, however, there may be free hæmorrhage in a few

cases, as frequently small vessels and sometimes large ones pass from the capsule to the surface of the kidney. This danger of hæmorrhage is not great, as the divided vessels when normal in size soon close. It is otherwise when the indurated tissue around is injured. The tissue being

FIG. 190. FORCEPS FOR CLAMPING THE RENAL PEDICLE.

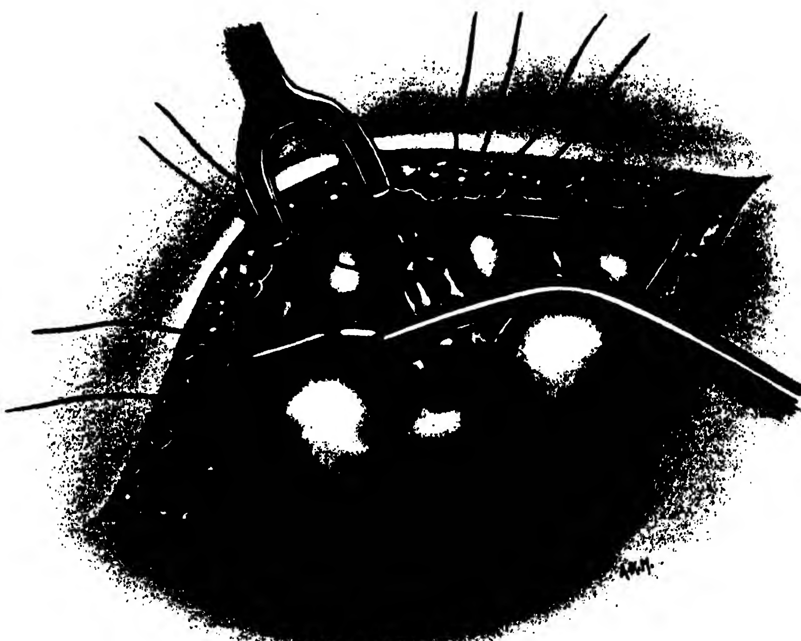


FIG. 191. THE PEDICLE OF THE RIGHT KIDNEY CLAMPED AND TIED.

not only vascular, but greatly indurated, the vessels passing through it gape when divided, and show no tendency to contract. Hence, the bleeding which occurs when the inflamed perinephritic tissue is cut or injured is a general oozing, large in amount and sometimes even dangerous.

The kidney having been freed and delivered with the hand or with the help of forceps (see Fig. 192) and the pedicle exposed, it should be clamped with forceps (see Fig. 190), and a double chromic catgut ligature should be passed round the vessels, and another round the ureter, by an aneurysm needle (see Fig. 191). The kidney is then dragged gently outwards, and the needle having been withdrawn the ligatures are tied. While one set is made to include the vessels the other set secures the ureter. Having fixed the ligatures, the last step ofthe operation is proceeded with, and the organ is removed by cutting the pedicle between the ligatures as close to the hilum as possible with curved scissors cutting on the flat.

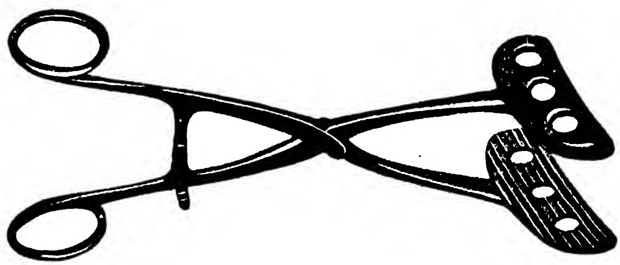


FIG. 192. FORCEPS FOR DELIVERING THE KIDNEY ON TO THE LOIN.

After the division of the pedicle the renal artery should be tied separately, also the vein, and the ureter should be traced down as low as possible, two ligatures applied, and the duct divided between them so as to avoid escape of contaminating fluid. The lumen of the stump should be painted with pure phenol and the end stitched carefully. Then a thorough search should be made in the interior of the wound, which is now easily inspected, for any bleeding points, and these having been secured a drainage tube is inserted, and the wound is washed out with an antiseptic solution. The lips of the wound are brought together, and an antiseptic dressing is applied. For statistics see p. 403.

ABDOMINAL NEPHRECTOMY

Abdominal nephrectomy may be performed either by an incision at the outer margin of the rectus muscle, or by one in the linea alba.

Lateral abdominal nephrectomy. This method, also called Langenbuch's operation, is performed as follows: The patient being placed upon his back, an incision is made in the linea semilunaris on the side of the diseased kidney (see Fig. 193). The length of the incision in the parietes is regulated by the size of the organ to be removed. All superficial vessels having been secured, the cavity of the abdomen is opened, and, the intestine which protrudes having been pushed aside, a careful examination of the diseased kidney and its fellow is made. Should both be seriously diseased, the operation should

not be proceeded with, but if the other kidney be presumably able to do its work, the next step is to expose the posterior or outer layer of the mesocolon, by pushing aside the intestines. The mesocolon is then incised vertically, and an opening is made of sufficient size to admit one or two fingers behind the peritoneum (see Fig. 194).

The anterior lips of both peritoneal wounds, that of the abdominal wall and that of the mesocolon, should now be united by closely set sutures of catgut, for the purpose of shutting off the cavity of the peritoneum from the space occupied by the kidney. Langenbuch's purpose was to divide the outer layer of the mesocolon, so as to reduce the risk of hæmorrhage and of gangrene of the bowel. Care must now be taken, as in the lumbar operation, to avoid hæmorrhage. When the peritoneum has been stripped off by the finger, and the kidney freed from its surroundings, the pedicle should be secured, as in the lumbar operation, and then the kidney may be enucleated and a drainage tube introduced into the wound, so as to maintain the communication between the post-peritoneal space and the exterior.

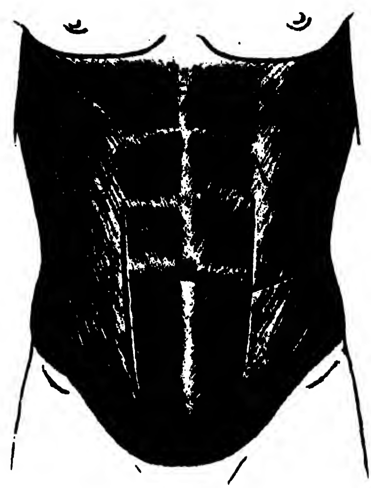


FIG. 193. LANGENBUCH'S INCISION FOR TRANSPERITONEAL NEPHRECTOMY.

Even although the kidney has been free from adhesions and there is not much danger of hæmorrhage, a drainage tube should always be employed, both in this operation and the following one; but while in the former the drainage tube may be brought out through the operation wound, in the latter a small opening should be made for the tube posteriorly.

Median abdominal nephrectomy. The incision for median abdominal nephrectomy is the same as for ovariotomy. When access to the abdominal cavity has been gained by a section through the linea alba, the principal difficulty to contend with is the hæmorrhage, which is apt to occur as a consequence of incision or laceration of the large veins in the anterior layer of the mesocolon. The incision in that structure should be made in the line of the veins, and if it be found necessary to divide any of these vessels, they should be previously secured by ligatures. When the kidney has been thus safely reached, the remaining

steps of the operation are the same as in Langenbuch's. In all cases a drainage tube should be introduced from behind, and, all blood-clot having been removed from the space formerly occupied by the kidney,

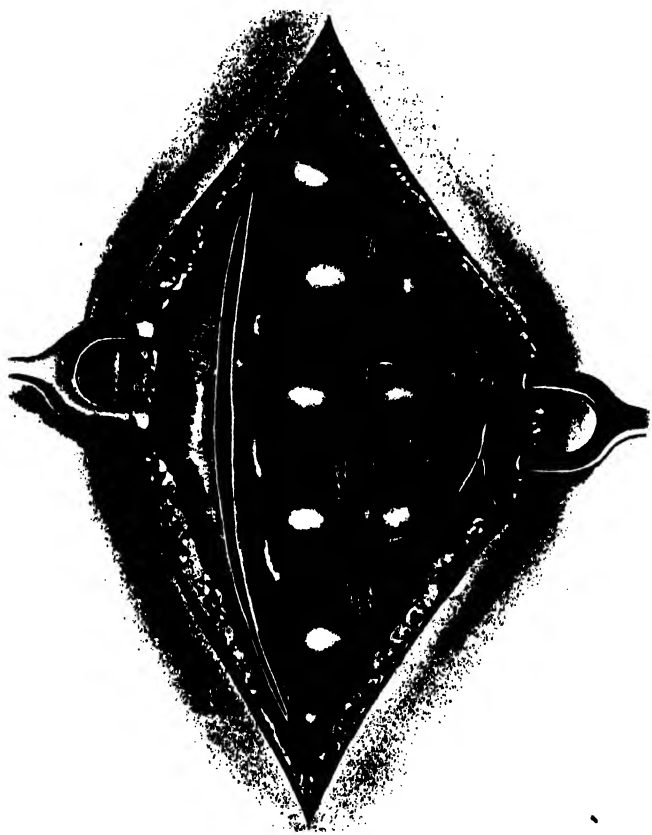


FIG. 194. INCISION IN THE OUTER LAYER OF THE MESOCOLON IN TRANS-PERITONEAL NEPHRECTOMY ON THE RIGHT SIDE.

the anterior and posterior peritoneal wounds should be carefully united by fine chromic catgut sutures, and subsequently the wound in the parietes should be brought together, as in ovariotomy. For statistics see p. 403.

PARTIAL NEPHRECTOMY

Indications. Partial nephrectomy is an operation not often employed, although it has occasionally proved useful in the treatment of injuries to the kidney, simple neoplasms, small malignant tumours in the cortex, and limited tuberculosis. Partial excision of the kidney has been recommended in the treatment of tuberculous disease, but is not so suitable an operation for that malady, even when it is seemingly limited in extent, as for lesions such as perinephric tumours and other localized growths in the cortex of the kidney which only involve a small portion of the organ.

Operation. The kidney having been brought out on the loin, the pedicle should be gently clamped with the kidney forceps. The nature and extent of the lesion are carefully ascertained, so that the surgeon may determine the amount of kidney requiring to be removed. An angular incision should be made wide of the diseased focus and a wedge-shaped segment removed. The two cut surfaces may then be brought together with catgut sutures.

Dangers of Nephrectomy. The causes of death in nephrectomy in percentages are as follows :—

Uræmia and anuria	18·5 %
Shock	30·2 %
Death during operation	1·1 %
Sepsis, peritonitis, &c.	21·0 %
Hæmorrhage	3·2 %
Rapid recurrence of disease	4·1 %
Complications in other organs: empyema, pleurisy, pneumonia, Bright's disease, cardiac or pulmonary embolism, &c.	21·9 %
	100·0 %

Shock is one of the most serious dangers, but considering the general condition of many patients who are submitted to the operation, the mortality from this cause is not to be wondered at. Within late years the statistics have improved greatly, and this is accounted for by the fact that the surgeon is consulted at an earlier stage in the disease than formerly. Some cases do remarkably well for three or four days after the nephrectomy, but die suddenly from what has been called 'delayed shock', attributed by some writers to interference with the solar plexus. Any such cases which have come under the observation of the writer have proved to be due to embolism on the right side of the heart, probably caused by a thrombus carried from the stump of the renal vein or vena cava.

Hæmorrhage. By clamping the pedicle before removal of the kidney

and carefully ligaturing the individual vessels as well as the stump as a whole, comparatively little blood should be lost during the operation, and the danger of secondary hæmorrhage reduced to a minimum. It is where old inflammatory adhesions and large masses of indurated tissue have to be cut through that both primary and secondary hæmorrhage are to be feared.

Peritonitis is one of the special dangers of the transperitoneal operations, but even in lumbar nephrectomy the peritoneum is liable to become infected owing to the detachment of old adhesions; hence the advisability of performing subcapsular nephrectomy when it is possible. This method has the further advantage that the suprarenal body and solar plexus are not interfered with. If the peritoneum be opened in the lumbar operation it should be cleansed and sutured at once. It is a safe rule to follow that all septic and tuberculous lesions or conditions involving accumulations of fluid in the renal pelvis should be removed by the lumbar method, while abdominal nephrectomy should be reserved for the excision of large solid growths of the kidney.

Empyema. As has been pointed out previously, the diaphragm is very thin behind the kidney, and the pleura extends down to the twelfth rib. The writer has seen a number of cases in the post-mortem room where a congenital gap existed in the diaphragm which was plugged by the perinephric fat; had a nephrectomy been demanded in such a case the danger of opening the pleura would have been considerable.

Pulmonary and *cardiac embolism* may occur any time within a fortnight after the operation, even though the renal wound be completely healed. The course of events and the symptoms, of course, depend upon the thrombus being aseptic or infected; if the former, it is generally large in size and may lead to sudden death from cardiac failure; if the latter, probably the particles are small, and are more likely to induce septic infection of the lungs or general septic poisoning.

GENERAL STATISTICS OF RENAL OPERATIONS

The comparative dangers of lumbar and abdominal nephrectomy are difficult to contrast fairly, seeing that undoubtedly during recent years the latter operation has been reserved for cases where the lumbar method was unsuitable on account of the advanced stage of the disease and the large size of the kidney to be removed. Taking the average mortality, that of the lumbar operation is 23·5 %, the abdominal, 39·9 %; but if we take the statistics of the last five years only, 1904–8 inclusive, the mortality is distinctly less, viz. lumbar 18·3 %, abdominal 31·3 %.

In August, 1871, Simon performed the first nephrectomy for renal calculus pure and simple. During the first ten years—that is to say,

from 1870 to 1879—fifty-seven renal operations were performed with a mortality of twenty-nine or a little over 50 %.

Renal Operations from 1870 to 1879.	Mortality.		
	Nephrotomies.	*Nephrolithotomies.*	*Nephrectomies.*
For hydronephrosis and cystic disease .	0 %	-	71 %
For septic disease without calculus .	36·1 %	-	50 %
For septic disease with calculus . .	—	54·5 %	66·6 %
For tuberculosis	25 %	-	100 %
For tumours	—	—	58·3 %

During the next five years, from 1880 to 1884, 219 operations were performed, two-thirds of which were nephrectomies. Indeed, at this period nephrectomy was resorted to very freely and was adopted as the only remedy for conditions which are now treated by less heroic measures. The mortality all over was seventy-one, or about 32·5 %—a decrease of 17·5 % on the mortality of the previous ten years.

Renal Operations from 1880 to 1884.	Mortality.		
	Nephrotomies.	*Nephrolithotomies.*	*Nephrectomies.*
For hydronephrosis and cystic disease .	0 %	—	33·3 %
For septic disease without calculus .	21 %		40 %
For septic disease with calculus . .	—	26·3 %	34 %
For calculus	—	0 %	0 %
For tuberculosis	25 %	—	39 %
For tumours	—	—	54 %

These statistics serve as a basis to illustrate the progress of renal surgery during the first fifteen years of its growth. The writer has endeavoured to collect the statistics of cases published from 1891 to 1908.

Renal Operations from 1891 to 1908.	Mortality.				
	Nephropexy.	*Nephrotomies.*	*Nephrolithotomies.*	*Nephrectomies.*	
				Lumb.	*Abd.*
Movable kidney . .	1·8 %	—	—	—	—
For hydronephrosis and cystic disease . .	—	6·2 %	—	19·3 %	31·1 %
For septic disease without calculus . . .	—	7·7 %	—	25·3 %	43·2 %
For septic disease with calculus . . .	—	—	8·7 %	23·5 %	45 %
For calculus (non-septic)	—		1·8 %	—	—
For tuberculosis . .	—	10·7 %	—	27·4 %	33 %
For tumours. . .		—		22·1 %	47·1 %

CHAPTER VI

NEPHROPEXY

Indications. Nephropexy should be recommended:

(i) In all cases of uncomplicated movable kidney in which the pain is distinctly renal—in which renal crises occur repeatedly, are well marked, and are referable to a definite cause.

(ii) Where there is evidence that the displacement causes twisting of the pedicle of the kidney, as indicated by paroxysmal renal pain, and the presence of such abnormal constituents in the urine as albumen, blood, pus, or tube casts.

(iii) When gastro-intestinal symptoms are pronounced while the patient is active, but relieved while she is at rest, the operation should be advised as a curative measure.

The operation should not be recommended when the symptoms distinctly referable to the mobility of the kidney are a small part of the trouble.

In movable kidney complicated by enteroptosis, an operation should not be recommended unless it can be shown clearly that serious symptoms are directly due to the displacement of the kidney. For example, in a case of general relaxation of the abdominal walls following frequent pregnancies, where the whole of the contents of the abdomen occupy a lower and more anterior position than normal, associated with chronic dyspepsia, constipation, and symptoms of uterine displacement and perhaps with hernia and hæmorrhoids, nephropexy should not be performed unless the displacement of the kidney is causing symptoms of torsion of the pedicle.

When movable kidney is associated with a highly nervous temperament, all palliative means should be employed before suggesting an operation. But it must be remembered that in neurotic patients the suffering arising from movable kidney is often exaggerated. Also mobility of the kidney in many instances not only determines the origin and distribution of the pain, but in like manner is itself a fruitful cause of hypochondriasis. When the neurotic phenomena are due to pressure of the kidney on other abdominal organs, the question of nephropexy may be considered; but the patient or her friends should be warned that the operation may not produce a cure.

When long-standing dyspepsia and chronic constipation are present,

or when chronic uterine or ovarian disease or cystic or chronic organic disease of the kidney coexists with mobility of the organ, nephropexy should not be performed, nor should it in those cases in which the displacement does not give rise to much discomfort or functional disturbance, the mobility of the organ being discovered probably by accident.

Nephropexy has now completely taken the place of nephrectomy for the treatment of movable kidney. The advantages of nephropexy over extirpation of the kidney are so obvious, that it is unnecessary to state them. Extirpation is only permissible where nephropexy has failed and

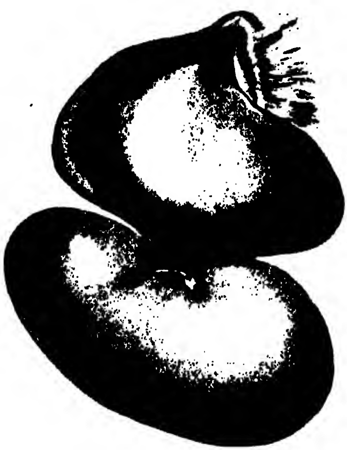


FIG. 195. SUDDEN BENDING OF THE URETER, CAUSING HYDRONEPHROSIS IN A MOVABLE KIDNEY.

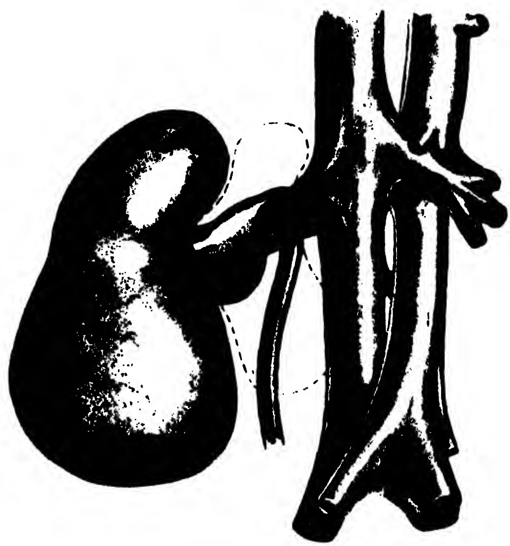


FIG. 196. ROTATION OF A MOVABLE KIDNEY. The ureter is twisted round the vessels.

where the patient's life is still seriously threatened, when the movable kidney is diseased and the fixed kidney healthy.

Operation. The methods of operation may be divided into two classes: those in which the operation is performed without, and those in which the operation is performed with decapsulation.

The preliminary stages of the operation are the same as for lumbar exploration (see p. 278).

Methods without decapsulation. Many early nephropexies were performed without removing the capsule; but, as the operation frequently proved ultimately unsuccessful, this method has been practically abandoned.

A movable kidney that is the seat of a pyonephrosis, or of an abscess

which has been evacuated spontaneously or by operation, becomes as a general rule firmly fixed by inflammatory adhesions. So a cure follows operations upon the kidney for such conditions as calculus and tumour or curetting for tuberculous disease. In a few cases the writer has simply removed the whole of the peri-renal fat (in a small proportion of these, laid bare the surface of the quadratus lumborum and psoas muscles) and packed the space around the kidney with gauze. The skin and sub-cutaneous tissue are accurately sutured over the plug of gauze except at the posterior end, where an opening is left, with the gauze lying in it, so as to act as a drain and to allow of its with-drawal. The gauze is allowed to remain *in situ* for eight or ten days for the purpose of causing any remaining adipose tissue to break down and be discharged, also in order to excite adhesive inflammation. When the gauze is withdrawn on the eighth or tenth day, the cavity of the wound should be irrigated, and a small strip of gauze or drainage tube inserted. The principle on which this method is based is that the broad band of fibrous tissue developed between the organ and the parietes is more likely to anchor the kidney firmly than when healing by primary union is aimed at.

FIG. 197. METHOD OF SUTURING THE CAPSULE OF THE KIDNEY TO THE MUSCULAR PARIETES.

Methods with decapsulation. In the great majority of cases it is

necessary to separate the fibrous capsule covering the convexity of the kidney.

After the kidney has been exposed the adipose capsule is removed along the convex border, one catgut suture is passed through the cortex at the lower, and another at the upper pole of the kidney, so as to fix the organ between the deep lips of the wound. The fibrous capsule is then incised and peeled off, so as to expose the raw surface of the cortex, and the cut edges are sutured to the muscular parietes (see Fig. 197). The sutures through the cortex are then fixed to the deep aponeurosis, the muscular wall is stitched in layers, the skin united by silkworm-gut, and the wound allowed to heal by first intention, no drainage tube or packing being employed.

The method just described aims at inducing immediate union between the surfaces of the kidney and the parietes. While in most instances a good result has been obtained, union by granulation is the proper object we should have in view in the majority of cases. Undoubtedly healing by granulation is a slower process than healing by immediate union, but the ultimate result justifies the sacrifice of a little more time in bed. The length of time a patient should be kept in bed after nephropexy has been variously stated by different surgeons. It is always safe to allow the patient out of bed during the fourth or the fifth week. No doubt in many instances an earlier date might be fixed; but a few days longer in bed is not a great tax, while it secures more complete union between the kidney and its surroundings. There is nothing special otherwise in the after-treatment. For statistics see p. 403.

Results. Much misunderstanding exists regarding the value of operating upon movable kidney, and this has arisen from the circumstance that the cases have not been properly selected. Well-marked instances have been recorded where nephropexy has been performed, the mobility of the kidney being but a small part of the illness.

NEPHROTRESIS

Indications. (i) The most urgent condition demanding this operation is obstruction to the excretion of urine, and in considering the question of operation a clear distinction must be drawn between true and false anuria. The former (*secretory anuria*) includes cases in which the function of the organ is entirely suppressed, as in diffuse nephritis, under toxic influences and infectious diseases, in tumours of the kidney, disease of one kidney and absence of the other, and in reflex anuria. The latter (*excretory anuria*) is caused by obstruction to both ureters or obstruction to one ureter, while the secreting power of the other kidney is impaired.

Whatever the cause of obstruction may be, it must either be removed at once or nephrotresis must be performed. In cases of unilateral obstructive anuria as well as in bilateral, if the surgeon be in doubt as to the capacity of the kidney first operated upon to sustain life, both should be opened. Reflex suppression in an unobstructed kidney is more common than is generally supposed (see *Report of International Association of Urology*, Paris, 1908). In secretory anuria incision and relief of tension often restore the function as a consequence of the blood-letting and by permitting passage of the urine from the uriniferous tubules.

(ii) When a ureter is obstructed by a condition which cannot be removed. As soon as this is proved, the pelvis of the kidney should be opened and drained in order to save the kidney from the destruction which is otherwise certain to follow.

(iii) In cases where the ureter has been injured and the function of the duct cannot be restored by grafting the ends together.

Operation. The operation is the same as exploration and nephrotomy (see p. 378), only the drainage tube is kept in and the urine is collected as it forms.

In cases in which it is necessary to drain the kidney or bladder for a considerable period, it is a great comfort to the patient to be able to move about unhampered by bulky and often soaked dressings. Direct drainage by siphoning the urine into a suitable vessel permits the patient to go about with freedom. The skin and clothing are kept dry, the patient is not incommoded by the constant change of dressings, and considerable expense is saved. The method the writer used for the last five years has been found most useful, both in draining the bladder after suprapubic cystotomy, and the kidney in cases such as old-standing hydronephrosis and pyonephrosis; a description of it will be found in the *Glasgow Medical Journal* for September, 1907.

The rest afforded by a lumbar drain allows time for compensating hypertrophy of the opposite kidney to take place, and not infrequently permits of gradual absorption of inflammatory products, so that a ureter which has been more or less obstructed for a long period may again become patent. This may be demonstrated by injecting coloured fluid into the fistula, and if it appears in the urine escaping from the bladder then the question of closing the wound in the loin may be considered. If, however, the constriction remains permanent, the subsequent proceedings depend upon the relative amount of work done by the diseased kidney and its neighbour, which may be ascertained, not by measuring the quantities of fluid coming from the wound and from the bladder, but by estimating the amount of urea excreted by each organ; a kidney which is almost useless functionally may excrete more fluid than its healthy neighbour, but the excretion may be nothing more than water mixed with a little pus.

CHAPTER VII

OPERATIONS UPON THE URETERS

The conditions which demand operations upon the ureter, apart from the kidney, may be divided into two classes, *viz.* injuries to the ureter, and ureteral obstruction.

OPERATIONS FOR EXPOSURE OF THE URETER

In exposing the ureters the surgeon has the choice of various routes.

TRANSPERITONEAL EXPOSURE

The ureter may be exposed either by a transperitoneal or by an extra-peritoneal operation, but the former is now only employed when the surgeon is uncertain as to the situation and nature of the obstruction, or is doubtful as to whether one or both ureters are involved. A median incision may be employed under such conditions, but if there be no doubt as to which ureter is affected, the incision should be made along the semilunar line and curved towards the middle line at its lower end. There are many objections to the transperitoneal method: unless the ureters be considerably altered by disease they are difficult to find behind the abdominal viscera; the peritoneum is opened both behind and in front, and in the event of any leakage of urine from the ureter may become infected; the position of the wound does not permit of free drainage; and, finally, no additional information can be gained which cannot be ascertained by other and safer methods.

Operation. After the abdomen has been opened, the first point is to ascertain the position of the kidney and find the hilum. Then, passing the fingers downwards in front of the psoas muscle, the ureter may be traced as low down as the bifurcation of the common iliac artery. When diseased and distended, the ureter is more easily traced than in health, and often the stone can be felt occupying its lumen, while above the obstruction the greatly distended ureter is easily traced behind the peritoneum; indeed, it may be so dilated that, were it not outside the peritoneal cavity, it might be mistaken for small intestine. When the ureter is not the seat of serious pathological changes, when the sub-peritoneal fat is abundant and the intestine is over-distended with gas,

much difficulty may be experienced in tracing the course of the duct. The point at which it is most easily detected is where it crosses the brim of the pelvis. The method of opening the ureter is described on p. 416.

EXTRA-PERITONEAL EXPOSURE

This route is the one almost exclusively employed in exposing the ureter. During the early stages of the operation the position of the patient is similar to that for renal operations (see p. 378), but it is well to have him placed upon his back with the legs flexed and the thighs brought well up over the abdomen while exploring the pelvic portion of the duct.

The ureter may be exposed without opening the peritoneal cavity by any of the following routes:—

1. The lumbar route prolonged extra-peritoneally.
2. The paraperitoneal route used in exposure of the kidney by stripping the peritoneum from the abdominal parietes.
3. The hypogastric route, opening the bladder above the pubes and catheterizing the ureters.
4. The sacral route.
5. The perineal route.
6. The vaginal route.

The lumbo-ilio-inguinal route is the one to be recommended in the great majority of cases, the exceptions being those in which the calculus or stricture is known to be in the pelvic segment of the ureter.

The incision usually employed commences an inch below the last rib at the outer edge of the erector spinæ muscle, and extends inwards and downwards in front of the anterior superior iliac spinous process. The distance to which the incision is extended inwards depends upon the necessities of the individual case. If the patient be short and stout, the space may be increased by making a T-shaped addition to the above, or by incising a portion of the quadratus lumborum.

When the fascia transversalis has been exposed and divided the colon is seen. It should be retracted, and the hand introduced through the wound behind the peritoneum, when the kidney can be felt embedded in its adipose capsule. The soft fat is easily separated from the kidney, and after the organ has been fully exposed a systematic examination must be made before it is disturbed from its bed. The ureter should be searched, and if a stone be found, it may sometimes be pushed up into the pelvis and removed by an incision through the convex border of the kidney; generally this is easily accomplished, as the ureter is dilated above the point of impaction of the stone, but if it be firmly fixed an incision should be made through the wall of the ureter above

the level of the stone, and after the calculus has been extracted the incision may be closed by sutures.

If the kidney has been removed and the tissues around it be indurated and adherent, it is very difficult to detect the ureter. Under such circumstances it is necessary to trace the ureter from below upwards, beginning at the point where it passes over the brim of the pelvis, or where it crosses the iliac vessels. In disease it is usually more easily discovered than in health, but on account of prolonged irritation the peritoneum is more firmly adherent to it than under normal conditions. When the duct is discovered by the forefinger the intestine and the peritoneum should be gently pressed aside with a thin gauze pad held by an assistant, in such a way as to leave the ureter freely in view. The serous membrane should then be carefully dissected from the duct as far down as may be necessary. Whether to separate the ureter upwards or downwards from the point in view is easily determined by its lumen; the duct is always distended above the point of obstruction.

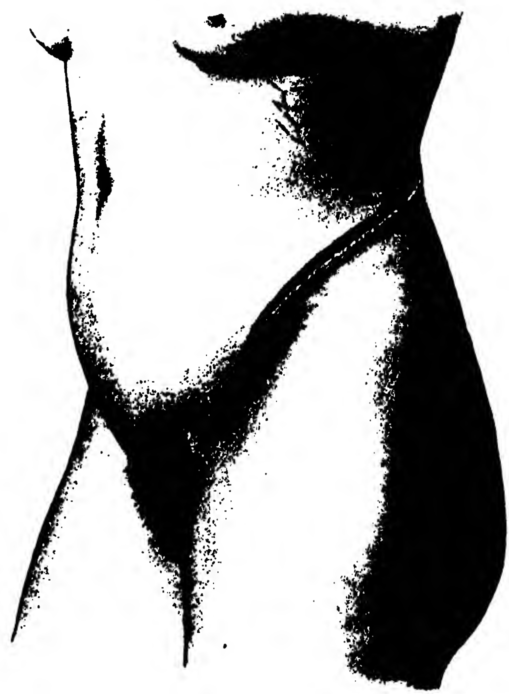


FIG. 198. THE LUMBO-ILIO-INGUINAL INCISION FOR EXPOSING THE URETER.

The pelvic segment can only be seen by extending the incision in the parietes well forwards, but before doing this it is well to pass the forefinger down into the pelvis and explore, and not infrequently, if the obstruction be due to stone, the concretion can be displaced so as to be brought into view without enlarging the opening.

A difficulty occasionally met with, which should be kept in view, is the lodgement of the stone in a diverticulum of the ureter, so that while the concretion is not in the lumen of the duct its presence causes distortion of the passage and obstruction to the escape of urine (see Fig. 199).

In opening the ureter, an oblique incision should be employed rather than a longitudinal one, which is liable to produce diminution in the

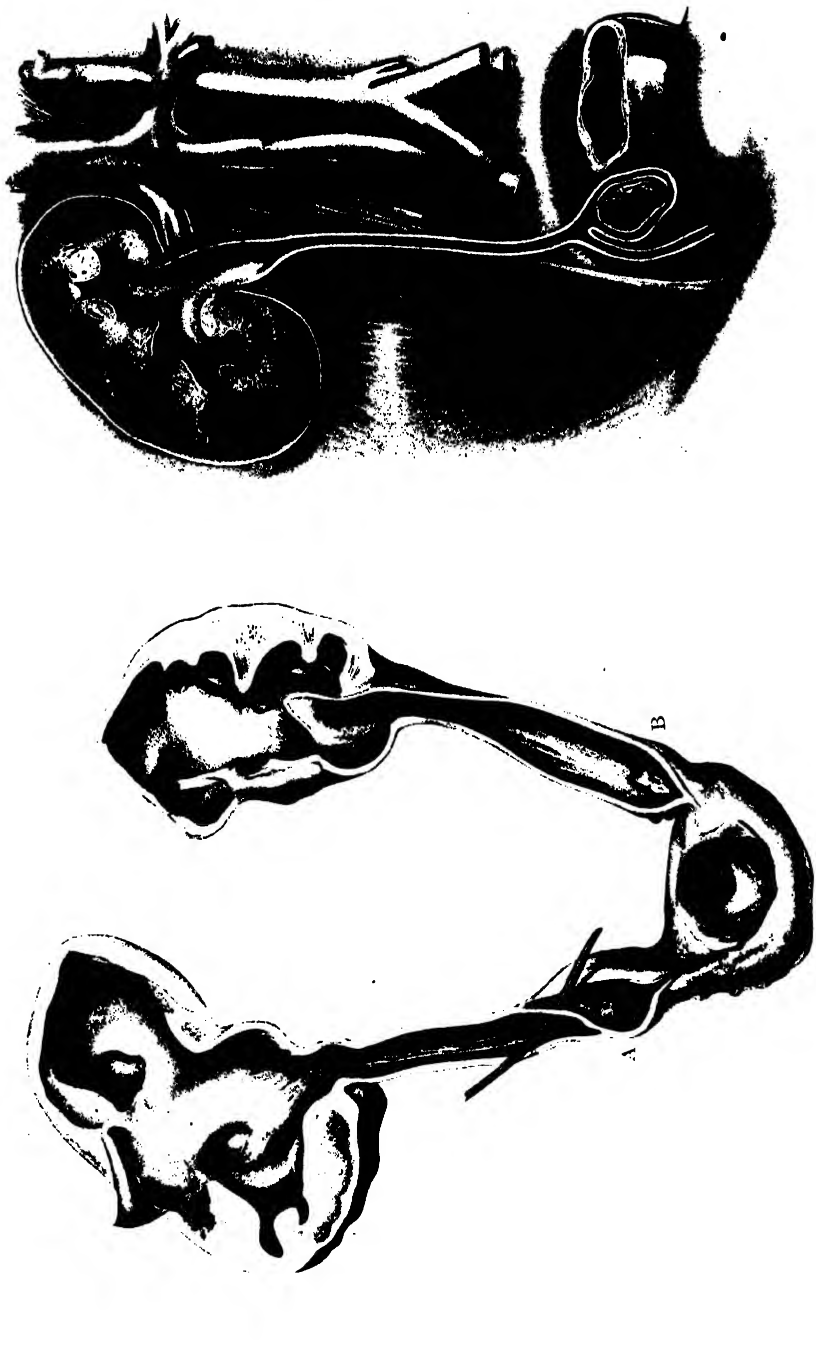


FIG. 199. IMPACTION OF STONES IN THE URETER IMMEDIATELY ABOVE THE BLADDER. In the left-hand figure the stone in the left ureter, B, is in the lumen of the duct; the one on the right side, A, is in a diverticulum. In the right-hand figure the stone is in a diverticulum.

lumen of the duct by the suturing, while a transverse incision is likely to be followed by a fistula.

When only the pelvic portion of the duct requires to be exposed, the incision through the parietes may be limited. Instead of starting from a point an inch below the last rib, the incision may be made as for tying the common iliac artery, commencing immediately outside the centre of Poupart's ligament and 1½ inches above it; this incision is carried outwards towards the crest of the ilium, then upwards and slightly inwards. The abdominal muscles are cut through till the fascia transversalis is reached; it is picked up and divided and

FIG. 200. IMPACTED URETERAL CALCULUS. The stone is arrested at the point where the ureter enters the bladder-wall. The duct is distended above the obstruction.

the extra-peritoneal fat is exposed to view. The peritoneum is then separated, and, with the bowel, is held to one side by an assistant while the surgeon explores the posterior wall of the bladder for the ureters. Owing to the small size and depth of the wound, it is necessary to throw light into it with an electric forehead-lamp or a mirror.

The paraperitoneal method is carried out in the following way: The patient is placed on his back and an incision is made ½ inch to the outer side of the linea semilunaris, beginning close to the border of the ribs and descending to the anterior superior spinous process of the ilium. The parietes are divided down to the peritoneum, the cavity of which is not opened, but the membrane is separated from the abdominal muscles gently by the hand of the operator and, along with the abdominal contents, is dragged towards the middle line by an assistant. The kidney with its surrounding fat is then brought into view and the ureter exposed and examined as described above.

Should the patient be short and stout, it may be necessary, in order

to gain sufficient room, to make an incision at right angles to the first one, possibly as far as the quadratus lumborum. The advantage of this method is not so evident in operations upon the ureter as when lesions of the kidney require to be dealt with, but it is certainly to be preferred to the transperitoneal route.

FIG. 201. URETERAL AND VESICAL CALCULI. The lower figure shows a calculus in the bladder in the sulcus immediately behind an enlarged prostate and another in the dilated end of the right ureter. The upper one shows a calculus impacted at the vesical orifice of the ureter only.

When old adhesions have formed, the peritoneum is very liable to be torn, and should this accident occur the wound must be carefully sutured before the ureter is opened.

The hypogastric route has been occasionally employed by the writer for the removal of calculi. If the stone has passed through the

muscular wall of the bladder and pushed the mucous membrane in front of it, the appearances presented by the cystoscope are liable to be mistaken for those of a tumour. In employing this method, the bladder is opened by a suprapubic incision (see p. 430) and the intramural segment of the duct is examined with one finger in the bladder, the other in the vagina or the rectum (see Figs. 200, 201). It may be possible to grasp the impacted body with forceps, and by careful manipulation drag it away without making any incision in the vesical wall; but if the stone be too large for this, it is well to make a small incision and dilate the ureter with sinus forceps before attempting to extract the calculus.

The sacral route has been employed by Sir Henry Morris (*Surgical Diseases of the Kidney and Ureter*, 1901, vol. ii, p. 526) for the removal of a calculus impacted 2½ inches from the orifice of the ureter. He describes the method as follows: 'I employed a straight incision parallel with the median line and 1 inch from it, 5 inches in length, commencing about 2 inches above the border of the gluteus maximus muscle and extending nearly to the transverse level of the anal aperture but a little behind it. The edges of the gluteus maximus and great sciatic ligament were divided, and the rectum and vagina were pushed towards the opposite side by breaking through the cellulo-fatty tissue between them and the pelvic wall by means of the forefinger and a few touches with the scalpel. In one of these cases the dorsal position, with the haunches well raised on a firm pillow placed beneath the loin, was found to facilitate the identification, isolation, and removal of the lower end of the ureter; in the other case the patient had to be turned upon her back before it was possible to fix the calculus. This was done by the forefinger in the vagina, and the patient was again placed on her opposite side with her face downwards and the calculus cut down upon and extracted.'

The perineal and the vaginal routes are also used for the removal of stones impacted close to the bladder, and for plastic operations for the cure of uretero-vaginal fistulæ. In the latter very good results have been got.

Ceci has removed a ureteral calculus through the rectum, and Fenwick has employed a perineal incision; removal through the vagina has been employed by the writer and others. In such cases, the ureter is dilated above the point of obstruction, so that it can be easily felt with the finger. The ureter and the stone should be fixed by a small sharp hook, and an incision is then made through the vaginal wall, cutting on the stone; when this is completed a rush of urine takes place, and the calculus escapes along with it. The opening may be closed with sutures, but probably it is safer to keep it open by passing a drainage tube into the dilated ureter.

URETEROTOMY

Ureterotomy includes simply opening the ureter in some part of its course, and how this should be done and the difficulties encountered in doing it are the points now to be considered.

Operation. The duct should be clearly brought into view, being freed as far as possible from its attachments, but at the same time care must be taken not to injure the peritoneum, the blood-vessels, or the spermatic cord. Instead of bringing the ureter out of the wound, an electric forehead-lamp or a good forehead-mirror should be used to throw a strong light into the depths of the wound, the operating room being darkened. Only about half the circumference of the duct need be cleared. An oblique incision is preferable to a longitudinal one, as the suturing of the edges is less liable to lead to constriction of the lumen than when a longitudinal incision is employed. Another method is to make a longitudinal incision, but to suture it so that the cicatrix is transverse (see Fig. 209), whereby the lumen, in place of being diminished, is rather increased. This method is, however, not always permissible on account of traction on the duct. When, however, the ureter has been dilated above the site of operation, there is generally plenty of tissue to work upon. When operating for stricture, the ureter should be opened at the dilated part above the obstruction, a director introduced, and the stricture divided upon it.

When the aim of the surgeon has been attained, the wound in the ureter should be closed by fine catgut sutures placed $\frac{1}{8}$ inch apart. These are introduced by a fine curved intestinal needle, which is made to penetrate the wall of the ureter with the exception of the mucous coat. While wounds of the ureter may doubtless heal without suturing, it is much safer to employ them, if Lembert's method be adopted and catgut be used.

URETERO-LITHOTOMY

When the ureter is exposed for the removal of a stone, if it be found that the calculus can be displaced from its bed and pressed upwards, the opening in the duct should be made in the dilated ureter well above the point of impaction. By adopting this plan the incision is made through comparatively healthy tissue, whereas if the cut is made directly over the concretion it passes through unhealthy tissue, the mucous membrane is apt to be eroded, and the walls of the ureter become thin and friable. After the stone has been brought to the opening in the ureter, difficulty may be found in removing it, as, if smooth and rounded, it

may repeatedly slip away from the grasp of sequestrum or dressing forceps. In such cases the writer has used cup-shaped forceps similar to Mackenzie's laryngeal forceps (see Fig. 202), or a small lithotomy spoon. Again, in cases of phosphatic concretion associated with bacillus coli infection, the stone may be so friable that it breaks into small fragments as soon as it is grasped with forceps. Here again a spoon is useful. After the stone has been removed, the ureter sound should be passed upwards and downwards to make sure that the duct is patent, that all concretions have been removed, and that no stricture remains.

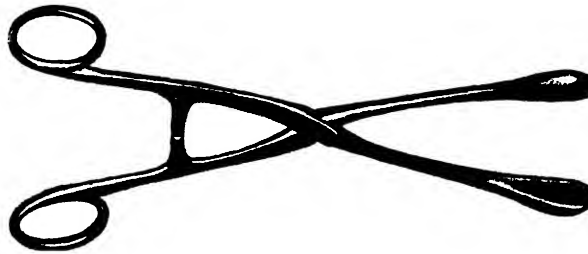


Fig. 202. Ureteral Forceps. Cup-shaped forceps with a special joint so that each limb can be introduced separately and locked when the stone is between the cups.

DERMATO-URETEROTRESIS

Transplantation of the ureter on to the loin is now frequently adopted, and the urine is drained into a suitable vessel, when it is found necessary to divert the secretion from its natural channel; for example, in ectopia of the bladder, in removal of the bladder for malignant diseases, or in certain cases of tuberculosis.

Operation. The incision is made parallel with and 1¼ inches above the crest of the ilium, the muscles are divided, and the peritoneum is exposed and pressed towards the middle line without the cavity being opened. The ureter is exposed where it crosses the iliac artery, ligatured in two places, and divided. The lower ligature is cut short, the upper is allowed to remain long. A seton lancet threaded with the suture is then passed through the abdominal walls, so as to come to the surface close to the border of the quadratus lumborum, and the ureter, carefully freed from its attachments, is dragged through after it and drawn out beyond the surface of the skin. The end of the duct should then be split open for about ⅓ inch longitudinally, and the two flaps folded over the skin to which it is sutured.

Care must be taken that there is no kinking of the ureter, and to prevent this a ureter catheter should be retained for four or five days until adhesion forms between the ureter and the parietes.

Implantation of the ureter on the skin has been resorted to in a considerable number of cases, Le Dentu being the first to employ it; but it seems to be justified not only in the conditions above mentioned, but also as a temporary measure or to save the patient from immediate death by anuria. It should only be resorted to when, owing to loss of substance, no other method is possible, or to tide over a critical period, after which another implantation may be made or nephrectomy performed. As a rule, if implantation cannot be made into some part of the urinary tract, and the kidney on the opposite side is healthy, nephrectomy should be performed.

ENTERO-URETERAL ANASTOMOSIS

The purpose of this operation is to lead the urine into some part of the intestinal tract, and it has been applied mostly in cases of ectopia vesicæ. It is described and illustrated by Mr. Thomson Walker (see p. 477).

This method is applicable to extroversion of the bladder only. For other conditions implantation of the ureter into the bowel should be avoided. Experimental implantation into the rectum, the colon, and the small intestine has been studied by Rosenburg, Novaro, Morestin, Tuffier, Gluck and Zeller, van Hook, and many others, but the operations performed upon animals contrast unfavourably with those undertaken on man. According to Bovee, bowel implantation has been done sixty-five times on man with a mortality of 30%, and a little less than a half of these deaths were from subsequent ascending infection.

URETERO-VESICAL ANASTOMOSIS

When the loss of substance has been too great to permit of uretero-ureteral anastomosis, grafting the end of the ureter into other parts has been resorted to. The most suitable one to employ is uretero-cystotomy or implantation of the ureter into the bladder. Vesical grafting has been carried out in four different ways: (1) grafting the ureter into the bladder through the vagina; (2) grafting the ureter into the bladder by an extra-peritoneal route, an incision being made through the abdominal wall for the purpose; (3) by an intraperitoneal operation; or (4) by dividing the vesico-vaginal septum and grafting the ureter into the bladder direct. The first operation, according to Bovee, was performed by Tuffier in 1877. The next operation was done by Novaro in 1893, and since that time eighty uretero-cystotomies have been per-

formed. Of these, thirty-seven were resorted to on account of accidental wounding of the ureter in abdominal operations. In such cases anastomosis with the bladder should be established as soon as the accident is discovered.

Operation. The cut end of the ureter should be split longitudinally for about ⅓ inch. An incision is then made obliquely through the wall of the bladder at the most convenient point, and a small sound introduced through the bladder is passed into the ureter. The cut end of the ureter is then pushed through the opening made in the bladder and carefully fixed by interrupted sutures through the wall of the bladder as indicated in Fig. 203. Retroperitoneal drainage should be established, and a catheter retained in the bladder for five or six days. This is the most satisfactory method of re-establishing something like the natural condition of matters, although it must be admitted there is a risk of stenosis being established; but when the end of the ureter is split before uniting it to the bladder the risk is considerably diminished.

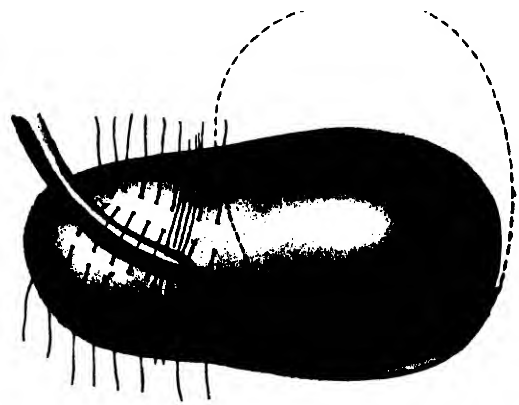


FIG. 203. URETERO-VESICAL ANASTOMOSIS. Method of suturing the bladder and ureter, so that when the sutures are tied the ureter is enveloped in a covering of the bladder-wall.

PYELO-URETEROSTRESIS

When there is obstruction at the junction of the infundibulum and the ureter on account of distortion or distension of the renal pelvis, the malformation may be rectified in various ways, according to the precise distortion which is producing the obstruction. Generally the obstruction is due to oblique insertion of the ureter into the pelvis of the kidney (see Fig. 204).

Operation. The kidney is exposed, the precise condition of matters is ascertained, and an attempt is made to bring the physical condition as near to normal as possible. This can frequently be done by resecting a portion of the pelvis of the kidney, but the part to be

removed depends entirely upon the condition found. When the distension is limited to the upper part of the pelvis, a segment of the sac can be removed and the cut edges united by interrupted sutures (see Fig. 205). When the lower part of the pelvis alone is distended and the ureter enters the sac at its uppermost limit, the best plan is to divide the sac on its outer aspect along with the ureter on its inner aspect, and to stitch the cut edges of the two structures to one another. The object

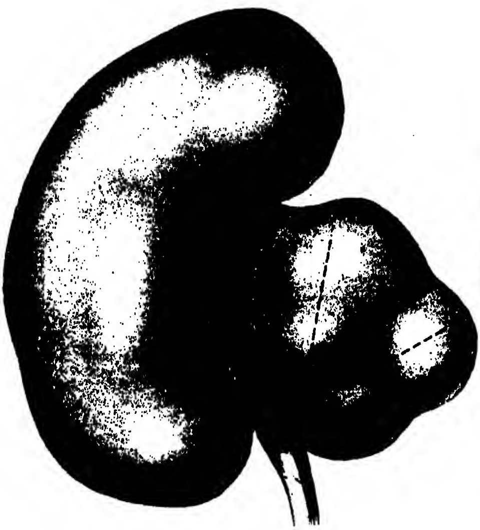


FIG. 204. OBLIQUE INSERTION OF THE URETER INTO THE PELVIS OF THE KIDNEY. The dotted line shows the segment to be removed.

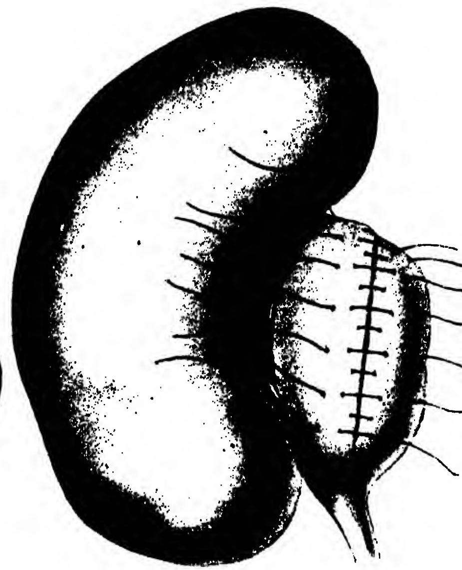


FIG. 205. METHOD OF SUTURING THE PELVIS AFTER RESECTION.

is to bring the ureter into communication with the most dependent portion of the sac, and in order to do this it may be necessary sometimes to remove a portion of the ureter and to suture the lower segment to a new opening in the pelvis, while the upper segment is removed, and the cut margins of the pelvis are brought together with interrupted sutures.

END-TO-END AND LATERAL ANASTOMOSIS

These have been done in four different ways: (1) *The transverse end-to-end method* (see Fig. 206) was first performed by Schopf in 1886. Transverse wounds of the ureter tend to gape, and there is considerable danger of stenosis at the point of union, but the advantage of this method

is that there is no loss to the length of the duct. This operation has been performed twelve times. (2) *The oblique end-to-end method* was devised by Bovee, and his patient was free from any symptoms referable to the urinary passages four years after the operation. (3) *The end-in-end operation* devised by Poggi from experiments upon dogs has been very successful. In this method the upper segment of the duct is invaginated into the lower segment, and if necessary the latter is split for a short distance. It has been performed nine times with one death.

Bovee's *oblique end-to-end method* is a very satisfactory one. The ends of the ureters are cut obliquely before suturing, which is carried out as indicated in Fig. 207. This method prevents a circular scar, and so probably is less liable to contraction. The number of sutures inserted must be regulated by the conditions of the individual cases.

FIG. 206.
TRANSVERSE END-TO-END URETERAL ANASTOMOSIS.

FIG. 207.
OBLIQUE END-TO-END URETERAL ANASTOMOSIS.
(*Bovee.*)

Van Hook's operation (see Fig. 208) of *lateral implantation* by invagination of the upper segment of the ureter into the side of the lower segment, and its retention by sutures, is most useful when there is undue lengthening of the ureter from stretching.

Van Hook's description of the operation is as follows :—

'Pass two very small cambric needles, armed with one thread of sterilized catgut, through the upper end of the ureter $\frac{1}{8}$ inch from the extremity, from within downwards, the needles being from $\frac{1}{16}$ to $\frac{1}{8}$ inch apart, and equidistant from the end of the duct. These needles are now carried through the slit in the side of the lower end of the ureter, into and down the tube for $\frac{1}{2}$ inch, when they are pushed through the wall of the duct side by side.'

By pulling upon the sutures the upper end of the cut ureter is drawn into the longitudinal slit in the side of the other segment. The three ends of the sutures are then knotted and the invaginated part of the duct is fixed. Half a dozen to eight sutures are then applied if necessary, and probably render van Hook's original operation more secure. If the operation be carried out intraperitoneally, a flap of peritoneum may be utilized in covering the ureteral wound. Whichever operation

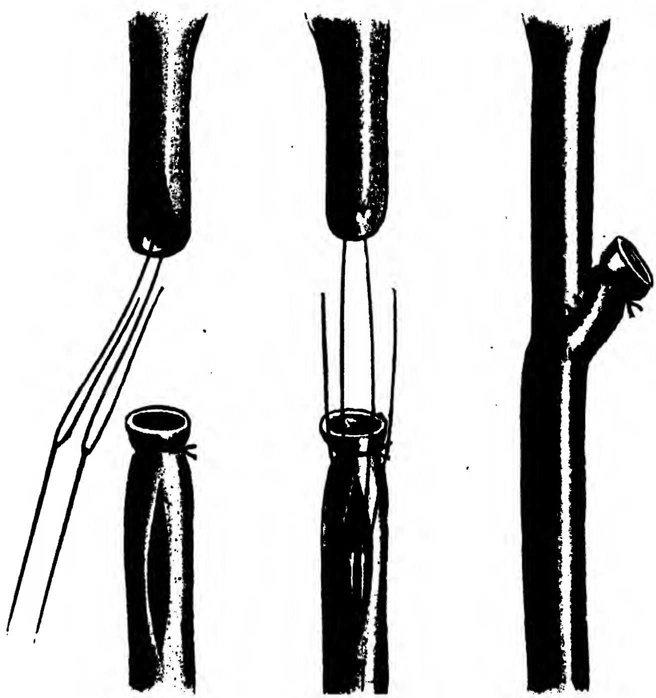


FIG. 208. VAN HOOK'S LATERAL IMPLANTATION OF THE URETER.

be employed, careful examination should make certain that the duct is permeable throughout, and an endeavour should be made to discover any congenital abnormality either of the duct or of the renal pelvis.

In the event of the anastomosis being effected low down in the ureter, it is a wise precaution to retain a catheter in the bladder for a few days, in order to prevent any strain upon the canal, as not uncommonly the mouth of the ureter has lost its contractile power where anastomosis is demanded. Drainage of the wound should be secured by means of gauze and rubber tubing.

URETEROPLASTY

Operation for the relief of stricture of the ureter is not often called for, but the lumen of the duct may be increased by the following method :—

Operation. The duct having been opened above or below the stricture, a catheter is introduced, and on the line of the catheter a longitudinal incision is made about ⅔ inch in length. The cut edges are

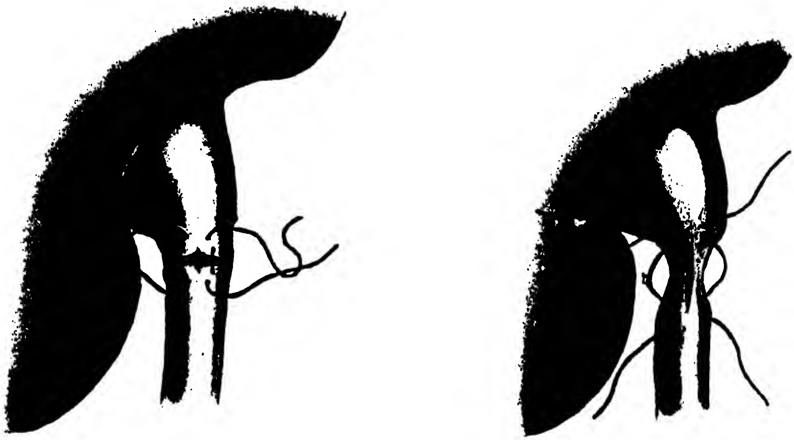


FIG. 209. URETEROPLASTY FOR STRICTURE.

then united by catgut stitches running parallel to the lumen of the duct, as indicated in Fig. 209. In this way the length of the canal is slightly diminished, but its lumen at the point of stricture is increased. Such a method of operating is, however, only applicable when there is not much induration of the wall of the duct. When it is thickened and dense the stricture should be incised and an oblique end-to-end anastomosis carried out if circumstances permit.

The sutures best suited for operation upon the ureters are catgut, treated so as to remain unabsorbed for a fortnight, and where possible the Lembert method should be adopted.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART II

OPERATIONS UPON THE BLADDER

BY

J. W. THOMSON WALKER, M.B., C.M. (Edin.), F.R.C.S. (Eng.)
Assistant Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

CHAPTER VIII

CYSTOTOMY

The bladder may be opened above the pubes (suprapubic cystotomy) or from the perineum (perineal cystotomy).

PERINEAL CYSTOTOMY

Indications. Perineal cystotomy may be used for :

(i) *Exploration of the bladder.* This is very seldom performed by this route at the present day. With a perineum of ordinary depth only a small part of the finger can be introduced into the bladder, and although assistance may be obtained by placing the free hand on the suprapubic region and pressing the bladder down upon the exploring finger, the area of the bladder that is explored by this means is extremely limited. If the perineum be deep or if the prostate gland be enlarged and the finger of the operator short, no more than the finger-tip may reach the bladder.

(ii) *The extraction of foreign bodies and calculi* is sometimes very difficult by this route, and only small calculi can be removed. The advantages that suprapubic cystotomy presents over perineal cystotomy in these operations are the complete exposure of the whole of the cavity of the bladder to the finger, to instruments, and, if necessary, to the view of the surgeon, and the possibility of extending the wound so as to meet any contingency. The superiority of perineal cystotomy in regard to rapid healing of the wound no longer exists; for, where rapid healing is desirable, the suprapubic wound may be closed at the time of the operation.

(iii) *Perineal drainage of the bladder.* This is discussed later (see p. 442). Perineal cystotomy is most frequently used in cases of stricture of the urethra, with or without fistulæ, where cystitis is present, or where a stone in the prostatic urethra is complicated by stone in the bladder.

Operation. The patient should be carefully prepared by a vegetable aperient followed by an adequate dose of sulphate of magnesia, and, on the morning of the operation, by a large soap and water enema. The perineum is shaved and cleansed, a curved staff with a deep groove on the convexity of the curve is introduced into the bladder, and the patient is placed in the lithotomy position.

The staff is held vertically by an assistant standing on the left side of the patient above the level of the pelvis. The assistant grips the handle of the instrument with the right hand and includes the lowest part of the scrotum in his grasp. The thumb is held vertically against the

FIG. 210. PERINEAL CYSTOTOMY. *First stage.* The tip of the left forefinger is directing the point of the knife into the groove in the staff in the membranous urethra.

FIG. 211. PERINEAL CYSTOTOMY. *Second stage.* The point of the gorget has been placed in the groove of the staff, which is being depressed towards the perineum by the operator's left hand.

roughened surface of the handle of the staff. The hand of the assistant inclines towards the abdomen so that the curve of the staff in the membranous urethra is pushed towards the perineum. The surgeon sits on a stool opposite the perineum. With a straight scalpel an incision 2 inches in length is made from above downwards in the middle line of the perineum,

ending ½ inch in front of the anus. This is deepened and the bulb is seen at the upper part of the wound. The staff is now made prominent in the membranous urethra by depressing the handle towards the abdomen, and the left forefinger of the operator seeks the groove on its convexity (see Fig. 210). The point of the knife is directed into the groove and the knife is pushed along horizontally until the blade is in the prostatic urethra. The membranous urethra is thus opened along its posterior wall

FIG. 212. PERINEAL CYSTOTOMY. *Third stage.* Introduction of the forefinger along the gorget into the bladder.

FIG. 213. PERINEAL CYSTOTOMY. *Fourth stage.* Exploration of the bladder with the left forefinger, and counter-pressure above the pubes.

and the commencement of the prostatic urethra notched. The knife is now withdrawn, still keeping the blade horizontal. A probe-pointed gorget or a Little's grooved director is introduced into the wound and pushed along the groove, while the surgeon takes the handle of the staff from the assistant with his left hand and raises it into a more vertical position, and as the gorget passes inwards and upwards, depresses it towards the perineum (see Fig. 211). A gush of urine shows that the gorget has entered the bladder. The staff is now withdrawn, leaving the gorget in position, and the forefinger of the left hand is introduced

along the gorget (see Fig. 212). The entrance to the bladder, with the patient in this position, lies well up behind the pubes, and is narrow and resistant. The finger must be pushed through it by a screwing movement. If the object of the operation is exploration of the bladder, the finger is pushed as far as possible through the sphincter, and the surgeon, turning the left-hand palm upwards, rises and presses the disengaged right hand on the suprapubic region, pushing the bladder downwards (see Fig. 213). The fluid should be allowed to escape from the bladder so that as much as possible of the wall can be reached by the finger.

If drainage be necessary the gorget is again slipped into the bladder and the finger withdrawn. A large rubber drainage tube (see Perineal drainage) is guided along this into the bladder.

SUPRAPUBIC CYSTOTOMY

Indications. This operation is the first stage of the various methods that will be described in the following pages for the drainage of the bladder, removal of stone and foreign bodies, the removal of growths, and the treatment of ulceration of the bladder and operations upon the prostate.

Operation. The pubes having previously been shaved and the suprapubic region prepared for operation, the patient is anæsthetized. A catheter is passed and the bladder distended with 12 ounces of warm boric lotion by means of a bladder syringe. If the urine be foul, the bladder should be filled and emptied repeatedly until the washing returns clear before the final distension. The catheter is left in the urethra, and the open end plugged with the nozzle of a full syringe which lies upon a towel placed across the patient's thighs. Over this sterilized towels are arranged which leave an uncovered space in the suprapubic region. The surgeon stands on the left side of the patient with an assistant opposite him and a second assistant, if such be available, at his left hand.

An incision, 2½ inches in length, is made in the middle line, commencing just below the upper border of the symphysis pubis and passing upwards. In a stout individual the incision through the skin and subcutaneous fat must be longer, but the deeper part of the wound does not exceed this size.

A vertical incision is preferable in the majority of cases, and it need seldom exceed 3 inches in length. In stout patients and in cases where the peritoneum is to be opened for any reason the wound may be extended. The incision here recommended will suffice for the most extensive intra-vesical operations. An objection to the vertical incision is that the recti prevent the full exposure of the front wall of the bladder. These muscles are usually lax under anæsthesia, but occasionally there is a spasmodic

rigidity of the muscles which is not abolished by deep anæsthesia. In such cases spinal analgesia is of service. More room may be obtained by incising the edge of the rectus on either side.

The operator holds aside the skin and subcutaneous tissue with the parted fore and second fingers of the left hand (see Fig. 214) and the anterior layer of the rectus sheath is exposed. This is cleanly cut through in the middle line. The pyramidalis and recti muscles now come into view. No time need be lost in seeking for a median partition between the muscles in this position. If it exists it is seldom seen and is of no importance. With

FIG. 214. SUPRAPUBIC CYSTOTOMY.
Incision of the rectus sheath.

FIG. 215. SUPRAPUBIC CYSTOTOMY.
Incising the bladder-wall.

the handle of the scalpel the longitudinal muscle bundles are separated in the middle line, taking care to make only one track between the coarse bundles. The knife is now laid aside, and the forefinger is introduced between the separated layers of muscle and seeks the upper limit of the symphisis pubis. Having found this the distended bladder can be felt behind it. The finger is now pressed directly backwards towards the surface of the bladder and the point of it hooked upwards. In doing this the layer of fascia transversalis behind the recti will be torn through, or the muscles may be retracted and this layer deliberately incised in the median line. The prevesical fat and the pocket of peritoneum which dips in front of the bladder are thus exposed. These are displaced upwards by a stroking movement of the finger, which at the same time hooks them

up from the bladder-wall. At this time the second assistant should uncover the full syringe which plugs the catheter and gently increase the distension of the bladder. The surgeon holds aside the fat and peritoneum at the upper extremity of the wound with his left forefinger and makes certain that the bladder-wall is exposed. This is recognized by the muscle fibres and the presence of large veins coursing longitudinally on its surface and also by the firm elastic sensation it imparts to the finger. If a pocket of peritoneum covers it the respiratory movements causing the abdominal contents to advance and recede will be plainly evident.

If any doubt exists in the mind of the operator, retractors may be placed to draw the recti muscles on either side and the anterior wall of the bladder fully exposed and viewed by the aid of a head-lamp. The bladder can now be felt as a fluid cushion. A scalpel held vertically a little above the pubic symphisis with the cutting edge away from it is plunged through the anterior bladder-wall with a stabbing movement (see Fig. 215). This puncture must be made boldly so as to avoid pushing the bladder mucous membrane before the knife. In withdrawing the knife the incision is extended a little upwards. The distending fluid wells up from the wound, the knife is quickly laid aside, and the right forefinger is inserted into the bladder wound and hooks up the wall before the bladder has time to collapse. Some surgeons recommend the use of a sharp hook to steady the bladder-wall while the incision is being made. This is introduced transversely in the middle line near the upper part of the exposed bladder-wall. The finger may now be replaced by a retractor which holds up the upper angle of the bladder wound in the middle line. The further procedure depends upon the object for which the cystotomy was performed.

Certain points in connexion with the technique of the operation will now be discussed.

Distension of the rectum. This method is very seldom employed at the present day, as it has been found that with it the elevation of the bladder base is not always sufficient to be of assistance, and the part of the anterior bladder-wall uncovered by peritoneum is not materially increased. Moreover, cases have been recorded in which rupture of the bowel followed over-distension of the bag.

Distension of the bladder. The capacity of a bladder is influenced by age and disease. In children 5 or 6 ounces may fully distend the bladder. In an adult male or female, 10 or 12 ounces will give a moderate distension if the bladder be not contracted. This is the quantity which is borne with comfort in a conscious patient, and with this amount the bladder is full but not over-distended. A catheter in

the urethra held erect and open will not discharge the fluid. The intravesical tension with this amount of fluid is therefore low. With an irritable bladder a less amount may be sufficient to cause vesical spasm, and the whole may be ejected, and sometimes the catheter may also be discharged from the urethra by the violence of the spasm. Spasm may be aroused by too rapid and forcible injection of the fluid and by the use of fluid that is too cold. Care must therefore be taken that the bladder is distended gradually, and that the temperature of the fluid is 108° F. Under an anaesthetic more fluid may be injected into the bladder, and even where the fluid has been spasmodically ejected several ounces may eventually be retained where patience is exercised. When there is difficulty in retaining the fluid in the bladder a turn of bandage may be placed round the penis, or an elastic band over a layer of lint; but this is seldom necessary, and

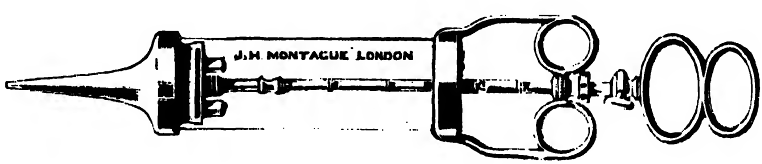


FIG. 216. BLADDER SYRINGE.

the method of plugging the catheter with a full syringe and increasing the fluid in the bladder after that viscus is exposed has much to recommend it. Over-distension of the bladder, especially where inflammation is present, may rouse the patient from a deep anaesthesia.

An atonic bladder will hold a pint or more without the intravesical tension being sufficiently increased to raise the fluid 6 inches in an open catheter. This is frequently observed in patients suffering from enlarged prostate. It is unnecessary to introduce more than 15 ounces before the bladder has been exposed, even in these cases.

The syringe must run smoothly and easily, for by means of the pressure which is exerted on the piston an idea of the intravesical tension should be gained. The best syringes have a stout glass barrel and an asbestos piston, and hold from $4\frac{1}{2}$ to $5\frac{1}{2}$ ounces of fluid (see Fig. 216). A solution of boric acid at a temperature of 108° F. is the most suitable medium, or solutions of oxycyanide of mercury (1 in 10,000) or biniodide of mercury (1 in 10,000) may be used.

The advantages that have been urged in favour of air-distension of the bladder are mainly theoretical. The danger of septic inflammation from the soaking of the wound with fluid used to distend the bladder is slight when the bladder has been carefully washed before commencing the operation and when proper attention is given to the wound by daily

lavage after the operation. The buoyancy of air is not required, even if it have the effect of raising the bladder to the abdominal wall with which it is credited. The approach to the bladder is quite simple when fluid is used. Neither air nor fluid should be introduced into the bladder under such pressure as will give the more compressible air any advantage over the less compressible fluid.

Cystotomy without distension of the bladder is necessary in some cases, such as vesico-vaginal fistula. If it be possible to pass a sound through the urethra this should be pushed well into the bladder. Especial care is necessary after incising the abdominal wall, to avoid wounding the peritoneum. The point of the sound in the collapsed organ provides a ready guide on which an incision is made. When the instrument is exposed the edges of the bladder wound are held up with catch-forceps and the wound extended with scissors. Von Dittel, who was the first to suggest this method, used a fully curved Bénique's sound. If no instrument can be passed into the urethra the operation is more difficult. The skin and recti muscles should be widely retracted and the bladder exposed with the aid of a powerful head-lamp, taking care to identify the peritoneum and dissect it up before opening the bladder.

The after-treatment of the wound. When the object of cystotomy has been attained, the question of treatment of the wound in the bladder-wall will arise. In some cases it is possible to close the wound by immediate suture, in other cases temporary drainage will be adopted, and in others permanent drainage must be installed.

Immediate suture is the ideal method of treatment, but is not always expedient. The following factors contra-indicate its use:—

Obstruction. After opening the bladder in a case of obstruction, it may be found impossible to remove the cause of the obstruction (malignant disease of the prostate). In such a case an attempt to close the bladder wound usually fails. Permanent suprapubic drainage will probably be necessary. On the other hand, it may be possible to remove the obstruction but inexpedient to proceed to the radical operation at once. Thus, in some cases of simple enlargement of the prostate, temporary drainage is indicated preparatory to the radical operation.

Sepsis. When cystitis exists, or when septic changes are present in the kidneys, immediate suture of the bladder is unwise. Obstruction and sepsis frequently combine to contra-indicate immediate suture.

Hæmorrhage. After the removal of bladder growths it is wise to place a drain in the bladder, unless the surgeon is convinced that all bleeding has ceased, and if oozing be still proceeding this is imperative. A small drainage tube or two tubes of small calibre are insufficient, for they quickly become blocked with clot, and a catheter tied in the urethra

is equally ineffectual. When the patient has been in the Trendelenburg position some minutes must be given, after replacing him in the horizontal position, for the circulation to readjust itself before concluding that no hæmorrhage will take place.

After removal of the prostate by the suprapubic route, free drainage of the bladder is imperative on account of one or more of these contra-indications.

The cases most favourable for immediate closure of the bladder wound are cases of cystotomy performed for aseptic calculi or for foreign bodies, and cases of operation for papillomata where the bleeding has been effectually controlled. To these might be added exploration of an aseptic bladder, but cystoscopy has replaced cystotomy in these cases.

If the edges of the bladder wound have been anchored by means of stitches, these are pulled up so that the bladder is brought into the abdominal wound. If no retaining sutures have been used, each lip of the wound is grasped at the middle with a pair of toothed forceps. The edges of the abdominal wound are well retracted. Interrupted catgut sutures are used, and pierce the perivesical tissues and the bladder muscle on each side, but do not penetrate the mucous membrane. The mucous membrane is loosely attached to the muscle and is easily avoided. The sutures should be closely set, about four to the inch, and commence at the apical end of the bladder wound. The first suture is placed a little above this end of the wound in Lembert fashion and tied. The remaining sutures pierce the edges of the wound, and each is tied after insertion and held up by an assistant. By this means gentle traction is exerted upon the bladder, so that the lower part of the wound gradually comes into view. Six or eight sutures may be required, and full curved medium-sized needles are employed.

When the bladder-wall is thin it may be necessary to pass mattress sutures, inserting the needle parallel with the wound, upwards on one side and downwards on the other, so as to get a good grip of the thin muscle. Some surgeons insert a row of Lembert's sutures over this first row of sutures.

Buried sutures of stout catgut are inserted in the abdominal wound by means of large curved needles. In these should be included the fascia transversalis, a thick bundle of rectus muscle, and the strong fascia in front of the rectus. Three or four of these sutures will be required, and a small calibre drainage tube is placed in the lower angle of the wound and reaches down to the closed vesical wound. This is removed in thirty-six hours if the wound remains dry. It should not be retained longer than two or three days, even if a little urine has leaked out. The skin is closed by interrupted silkworm-gut sutures.

The careful closure of the abdominal portion of the wound, whether a small tube be placed at its lower angle to drain the prevesical space or whether the bladder be drained by a large rubber tube, is a matter of supreme importance, since neglect of this precaution is likely to be followed by a hernial protrusion of the peritoneum at the upper part of the wound.

If proper drainage of the bladder and prevesical space be provided by means of tubes of suitable size there is no need to fear cellulitis even in septic cases.

After-treatment. Where the bladder wound has been closed in the manner above described, a silk-wove coudé catheter (No. 22 F.) is tied in the urethra and retained for four days. During this time the urine is allowed to drain continuously into a bottle between the patient's thighs. A careful watch is kept to prevent the catheter becoming blocked with clot. Should this occur a syringeful of boric lotion should be injected to clear the lumen.

If copious bleeding and intravesical clotting occurs, the catheter will be useless. In these cases the bladder usually fills up with clot, so that it can be felt above the pubes. It is wise in such a case to reopen the suprapubic wound without delay, clear out the clots, irrigate the bladder through the catheter with a copious stream of hot boric lotion, and place a large drainage tube in the bladder wound. The catheter may then be removed.

Should no such accident have occurred, the catheter is retained for four days and then removed. The patient is then directed to pass water without straining every two hours, and is wakened once or twice during the night so as to prevent the bladder being overdistended. At the end of a week no restriction need be placed upon micturition and the wound should be healed. Occasionally a slight leak occurs and continues for a week or ten days and then ceases.

The indications for bladder drainage and the methods by which it is carried out are considered on p. 442.

Difficulties and dangers. *Wounds of the peritoneum.* The peritoneum may be inadvertently opened when the bladder-wall is incised. This is usually due to want of care in freeing the prevesical pouch of peritoneum and pushing it up out of the way. Sometimes in inflammatory conditions of the bladder with pericystitis and in secondary operations upon the bladder the peritoneum is actually bound down to the front wall of the bladder. If this be recognized the membrane should be dissected up, but it may escape notice and the incision may cut through the peritoneum as well as the bladder. The opening is usually plugged by omentum, and the appearance of a piece of omentum may be the first

intimation that the peritoneum has been wounded. Occasionally the incision in the bladder wall is correctly made, but the wound is torn open by the drag of retractors or fingers and a rent made in an adherent peritoneum.

When it is recognized that the peritoneum has been incised or torn, the opening should be utilized to define exactly the lower limits of the pouch, and with the finger in the pouch the peritoneum should be dissected off the face of the bladder. Any excess of fluid at the opening should be mopped up, but no extensive disturbance of the viscera is necessary or advisable. The ends of the rent are picked up in catch-forceps and the wound closed by continuous or interrupted catgut sutures. In most cases the operation may be proceeded with, but if the urine is foul it will be wiser to place a large drain in the bladder, and postpone further interference.

Hæmorrhage. There is usually very little hæmorrhage during the operation of suprapubic cystotomy. Occasionally a vein in the bladder-wall bleeds, but this quickly ceases when the bladder collapses. An artery may be cut in the bladder-wall and require to be picked up with forceps. I was asked to see an unusual case of hæmorrhage in a patient on whom a colleague had performed cystotomy preparatory to prostatectomy. A general oozing from the bladder-wall and surrounding tissues commenced after the operation and resisted all local and general measures, and the patient died from loss of blood. There had been no signs of hæmophilia.

MODIFICATIONS OF SUPRAPUBIC CYSTOTOMY

Transverse suprapubic cystotomy. So long ago as 1730 Ledran [1] suggested the use of a transverse incision, but it was not until Trendelenburg [2] combined the transverse incision with the inclined position of the patient that the method became widely known.

Operation. The bladder is distended with fluid and the patient placed in the Trendelenburg position. The surgeon stands on the left side of the patient with an assistant opposite him. A transverse incision from 6 to 8 inches in length, according to the build of the patient, is made across the lower part of the abdomen. The incision is curved, with its concavity towards the umbilicus. In the middle line it lies 1 inch above the upper border of the pubic symphysis and at either extremity 2 inches above Poupart's ligament. The incision is deepened through the subcutaneous tissues and deep fascia to the sheath of the recti muscles. The sheath is cut through in the line of the incision

[1] *Manuel des différentes manières de tirer la pierre hors de la vessie*, 1730.
[2] *Berl. klin. Wochenschr.*, 1877.

and the recti and pyramidales muscles exposed. These muscles are cut through transversely. The recti muscles retract upwards, and some difficulty may be experienced in bringing them down when the surgeon comes to close the wound. It is advisable, therefore, before completely cutting through the recti muscles, to introduce one or two temporary sutures through the whole thickness of the muscles and sheath near the cut edge and clamp these with pressure forceps, using them for retraction during the operation, and for dragging down the muscles and sheath when the wound is being closed. The fascia transversalis beneath the muscles is cut through and the peritoneum exposed. The peritoneum is stripped off the front of the bladder and held aside with a broad retractor. The bladder is now very fully exposed and the reflection of the peritoneum on each side defined. A transverse incision is made through the wall of the viscus about the level of the upper border of the pubic symphysis. Higher up the bladder narrows towards its apex, and the incision would have to be more limited. When the bladder is opened precautions are taken to divert the fluid which escapes into a basin held at the side. The edges of the bladder wound are now picked up with toothed forceps, or several temporary sutures are introduced and the lips of the wound held aside. Instead of incising the bladder transversely, the incision may be made at any part of the wall and in any direction. Thus in removing a growth from the bladder the incision is placed so that the resection of the wall may be conveniently carried out.

The object for which the cystotomy has been performed having been accomplished, the surgeon will proceed to close the bladder wound and repair the abdominal wall. If no vesical drain be necessary, a continuous suture of catgut is made to close the wound in the bladder-wall. The stitches pass through the muscular coat without penetrating the mucous membrane. Over this a second row of Lembert's sutures of the same material is introduced. If drainage of the bladder be desired, a deep layer of interrupted sutures is used and reinforced by a second layer of Lembert's sutures.

The repair of the abdominal wall should be carefully performed. The patient is lowered into the horizontal position. The recti muscles and sheath of fascia are drawn down by means of the temporary sutures, and interrupted sutures of thick catgut are passed through the portion of recti muscles and sheath which remains attached to the pubic bones below and the free recti muscles and sheath above. Mattress sutures may be used, and one or two such sutures are useful towards the middle line, with ordinary interrupted sutures on each side. If bladder drainage has been adopted, room should be left for the tube and a second smaller

tube should be placed in the prevesical space. The skin wound is now closed with silkworm-gut sutures.

The advantage of the transverse incision is the free access which is gained to all parts of the bladder. The disadvantage is the damage which is inflicted on the abdominal wall. By careful suturing this disadvantage is reduced to a minimum, but for most operations inside the bladder the vertical incision gives sufficient exposure. For extensive operations upon the bladder-wall for the removal of growths the transverse incision is a valuable method.

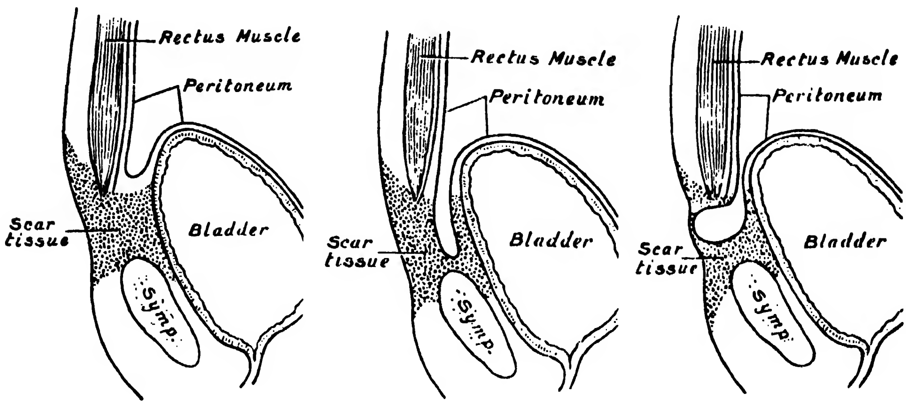


FIG. 217. THE CONDITIONS MODIFYING A SECONDARY CYSTOTOMY. A, The relation of the peritoneum to the scar and the bladder; B, A peritoneal process in the scar; C, Hernia of the scar.

Secondary cystotomy. Where cystotomy has been performed on some previous occasion, the following conditions may modify a second cystotomy: A small supple suprapubic scar which on dissection leads down between the recti muscles to the anterior wall of the bladder. The peritoneum is not involved in the scar (see Fig. 217, A). More extensive scarring may be present where there has been prolonged bladder drainage or widespread inflammation after the previous cystotomy. In these cases a pocket of peritoneum is frequently dragged down and fixed in front of the bladder, and is held down to the upper border of the pubic symphysis by fibrous tissue (see Fig. 217, B). Or a portion, usually at the upper end, of the scar is weak and a small pocket of peritoneum projects, covered by a thin layer of fibrous tissue (see Fig. 217, C). The bladder is frequently bound down to the posterior aspect of the pubic bones.

When no protrusion of the wound is apparent, the whole scar should

be removed by an elliptical incision vertically placed. By deepening the wound on either side the rectus sheath is exposed, and the scar should be removed at this level. The dissection should be carried carefully between the recti muscles, keeping well down to the upper border of the pubic symphysis until the finger can be passed behind the recti muscles. The wound is then extended upwards in the middle line, freeing the fibrous tissue by transverse cutting and pushing it upwards with the finger. By this means a pocket of peritoneum bound down to the upper border of the symphysis will be freed and pushed into the upper part of the wound out of the way. The peritoneum may still be adherent to the upper part of the anterior wall of the bladder. In order to expose the bladder muscle careful dissection and free retraction are required. Should intravesical manipulation be necessary, as it will be in the removal of growths of the bladder, it is usually necessary to dissect the bladder-wall from the firm adhesions which bind it to the posterior surface of the pubes. A large steel sound passed through the urethra with the handle well depressed will be of much assistance in these operations.

When a hernia of the scar is present the scar may be excised together with the pocket of peritoneum, the peritoneum stripped upwards off the bladder, and the peritoneal surfaces brought together with a continuous suture. When the operation is being performed for growth, the opening in the peritoneum may be used to obtain information in regard to its extent, or it may be necessary for the further steps of the operation if they involve the peritoneal surface of the bladder. When the operation is confined to cystotomy or the further steps are extra-peritoneal, the bladder may be opened, after closing the peritoneal wound with a continuous catgut suture and tucking a roll of gauze into the upper part of the wound. A transverse incision is preferable to the vertical incision in many cases of secondary cystotomy, and especially when an extensive intravesical operation is proposed.

Suprapubic cystotomy with resection of the pubic bones. In order to gain free access to the lower part of the anterior wall of the bladder some surgeons have resected portions or the whole of the pubic bones. Bramann[1] performed a temporary resection of a portion of the pubic bones. He makes a rectangular incision with the vertical portion in the middle line and the horizontal portion over the symphysis. With bone forceps and chisel the bone is divided obliquely on each side, commencing outside the spine of the pubes and passing down and inwards, and these incisions are joined by a transverse section

[1] *Deutsche Zeitschr. f. Chirurgie*, 1891.

of the bones. The fragment is separated from below upwards and carries the insertion of the recti muscles. The bone fragment is divided in the middle line and the right and left recti muscles separated, each carrying a fragment. The anterior wall of the bladder is thus exposed. After the operation the fragments are fixed to the body of the pubis by means of tacks.

Complete resection of the pubic bones was described by Ollier.[1] In order to preserve the vitality of the separated bone it is allowed to remain attached to the tissues at the root of the penis. An incision the shape of an inverted U is made through the skin with the convexity of the U 1 or 2 inches above the upper border of the pubes, and a vertical incision meets this in the middle line. The muscles are separated from the upper border of the pubic bones. The bone is cut on each side with a small saw and bone forceps. When the section is complete the whole flap is turned downwards and the front of the bladder exposed, taking care not to wound the retropubic venous plexus. After the operation the flap is replaced.

Suprapubic cystotomy combined with symphysiotomy. This operation was described by Tuffier and by Albarran[2] in 1892. A median vertical incision commencing 2½ inches above the upper border of the pubic bones is carried down to the root of the penis, and this is continued for half an inch on to the dorsum of the penis, and on each side for about an inch, forming an inverted Y incision.

The incision is deepened to the sheath of the recti muscles and the suspensory ligament of the penis cut through. The penis is now turned down and the lower border of the symphysis defined with the finger. The fibrous structures are incised down to the symphysis.

The recti muscles are separated, the prevesical fat exposed, and the peritoneum pushed upwards out of the way. A retractor is inserted into the space of Retzius and another drags down and protects the tissues of the penis. The symphysis is cut through with a strong scalpel exactly in the middle line from before backwards and from above downwards. The subpubic ligament is then carefully cut, avoiding the venous plexus of Santorini and the dorsal vein of the penis. A separation of 1½ to 2 inches may be produced without damage to the sacro-iliac synchondrosis. Having finished the operation upon the bladder, the cartilage of the symphysis is removed and the spongy tissue of the pubic bones exposed so as to obtain firm bony union. If the separation of the bones be moderate, the soft parts only need be sutured, but if it be considerable two sutures of silver wire are passed through the bones

[1] Rochet, *Chirurgie de l'urètre, de la vessie, de la prostate*, Paris, 1895.
[2] *Médecine opératoire des voies urinaires*, 1909.

and the prepared surfaces thus brought into contact. A drain is placed behind the pubic bones and the suprapubic portion of the wound united as in the ordinary operation. In addition to the usual dressings, a stout binder surrounds the bony pelvis and prevents any movement of the iliac bones.

By means of symphysiotomy a very free access is obtained to the lower part of the anterior wall of the bladder. The shock of the operation is, however, considerably greater than that of suprapubic cystotomy by the ordinary method. Albarran, who has used the method four times, believes that it is rarely necessary.

BLADDER DRAINAGE

Indications. Drainage of the bladder may be required as a temporary measure after operations upon the urethra or bladder or as a means of treatment of some cases of cystitis. Permanent drainage of the bladder may be necessary in cases of malignant disease of the prostate or bladder.

PERINEAL DRAINAGE

Where cystitis complicates a urethral or prostatic disease for which a perineal operation is performed, the bladder may be drained by the introduction of a perineal tube.

The best form of drain is a flexible rubber tube with a terminal opening and lateral eyes (see Fig. 312, p. 581). The edges of the opening are smooth and rounded. This tube is introduced just through the vesical sphincter, and its position tested by injecting a syringeful of lotion into the bladder and withdrawing the tube until it ceases to flow, and then pushing it on until the flow recommences. A silkworm-gut suture is passed through each lip of the perineal wound and through the tube and holds it firmly in position.

Another form of tube is a stiff gum-elastic tube with a large terminal and fine lateral opening at the vesical end and a metal ring with lateral eyes at the outer end. The tube is retained in position by passing a length of tape through each eye and carrying it along the fold of the groin in front and the fold of the buttock behind. The tapes are knotted on each side above the great trochanter, and attached to a waist-belt above this. To these perineal tubes may be attached a short length of rubber tubing, which lies in a urine bottle between the patient's thighs, or a longer tube may be attached which passes into a receptacle containing antiseptic fluid beneath the bed. The tubing is fixed at the edge of the bed by means of a loop of tape and a safety-pin, and a short glass tube interrupts the rubber tube at some point so that the flow of urine may be observed.

Drainage by this method may be maintained for four to seven days, and if it is desired to prolong it beyond this time a soft rubber tube should replace the rigid one. The perineal route is not, however, suitable for permanent drainage.

TEMPORARY SUPRAPUBIC DRAINAGE

Temporary suprapubic drainage is practised after the majority of suprapubic operations (see p. 434).

For this purpose a double tube of moderate calibre, curved at a right angle (Guyon's double syphon), may be inserted into the bladder wound, which is closed by a few catgut stitches around it. Another stitch through the skin and tubes holds them securely in position. This method was introduced with the object of washing the bladder by injecting fluid through one tube while the other drains it away.

A single tube of similar construction may be used and retained in the bladder by a double row of sutures through the bladder-wall, the second row being Lembert's sutures, so that the wall of the bladder is folded around the tube, and leaking is thus prevented (Gibson [1]).

If suprapubic drainage is to be efficient, it must be free. A rubber tube with a diameter of $\frac{3}{4}$ or even 1 inch will give more satisfactory results when sepsis is present or hæmorrhage in progress. The length of the tube will depend upon the depth of the abdominal wound. In a man of medium build about 4 inches will suffice, and this allows the tube to project slightly above the skin surface. A large lateral opening is made close to the vesical end. The tube lies just above the trigone, but does not press upon it. The bladder wound will usually grip a tube of this size firmly, so that no sutures are required to close the wall around it, and the bladder itself lies around the intravesical portion of the tube like a funnel. There is seldom any escape alongside a tube of this size. After the abdominal wound is closed a silkworm-gut suture is passed through the skin on one side and through the tube to hold it. A small tube or a wick of gauze is placed in the lower end of the wound and extends down to the prevesical space as a safeguard against leakage. Through a large tube such as this clots are readily removed with forceps, shreds of muco-pus extracted, and the bladder flushed with an adequate stream of antiseptic fluid. The abdominal wound should not be closed too tightly around the tube, as sloughing from pressure will result.

Where septic cystitis is present and infection of the pelvic areolar tissue is feared, the bladder-wall may be brought up and attached to the skin by a few stitches on each side. These sutures are cut after two days, by which time a sufficient barrier has formed against the spread

[1] *Medical Record*, 1901, lix, 45.

of infection. A voluminous dressing of wood-wool or cellulose tissue is kept in place by means of a many-tailed bandage with perineal straps. If no means of draining away the urine be provided the dressings become soaked and require changing every three or four hours.

Temporary suprapubic drainage is installed in many different conditions, and the length of time it is maintained will vary. After four days a track will have formed and the tube may be removed. From the time of the operation until the closure of the wound, a period varying from fourteen to twenty-one or more days, the urine wells up from the wound and soaks the dressings unless it is removed by some apparatus. To lessen the discomfort of the patient and reduce the possibility of irritation, the skin of the abdomen, scrotum, and the upper part of the thighs is smeared with an ointment containing equal parts of zinc oxide, lanoline, and vaseline.

Methods of draining away the urine. Many methods have been devised for the removal of the urine which will avoid the irritation of the skin and reduce the cost of the dressings. A few of these will be described.

1. *Exhaust methods. Cathcart's apparatus.*[1] This consists of a douche can filled with water and fixed above the head of the bed. From this a rubber tube conducts the water to a glass Y-tube, and the stem of the Y-tube to an S-tube and thence to a pail. The other arm of the Y is connected with a rubber tube which ends in the bladder. The water flowing from the douche can through one limb and the stem of the Y creates a negative pressure in the other limb and in the tube lying in the bladder. This suffices to draw the urine from the bladder into the Y-tube and it flows out with the water. The S-tube forms a trap which regulates the outflow, and the amount of water passing through is controlled by a screw clamp on the rubber tube between the can and the Y-tube. The water is allowed to flow only by drops. The negative pressure obtainable depends upon the distance between the branching point of the Y-tube and the end of the india-rubber tube leading to the pail. About a foot will usually suffice. Mr. Cathcart now interrupts the tube from the bladder to the Y-tube by introducing a bottle in the same way as in the next apparatus.

White's suprapubic evacuator.[2] This apparatus consists of a water-pump, a reservoir for the collection of urine, and bladder connexions (see Fig. 218).

(i) 'The pump consists of a narrow tube, terminating below in a small orifice and sealed into a larger tube with a side arm. The outer and larger tube is contracted below, and to it is attached about 2 feet of narrow rubber tubing terminating in a piece of fine lead piping bent round so as to prevent entry of air into the pump from below.

'The end is connected with a vessel containing water by means of rubber tubing, and the flow of water can be regulated by a pinch-cock.

[1] *Brit. Med. Journ.*, 1895.

[2] *St. Thomas's Hospital Reports*, vol. xxviii.

The water issuing from the fine orifice of the glass tube falls into the constricted neck below, and the diameter of this outflow tube is so small that successive drops of water falling into it carry down bubbles of air which cannot pass upwards through the water separating them owing to the fineness of the bore.'

'If the pinch-cock be so far closed that the drops of water fall at the rate of 50 to 100 per minute, an efficient vacuum is maintained with the consumption of only one or two pints per hour. A gallon reservoir of water is therefore sufficient for from four to eight hours' working.'

(ii) The separate collection of the urine is effected by interposing between the pump and the patient a receptacle having one orifice connected with the pump, by which it is rendered vacuous, and another with the bladder tube.

(iii) The bladder connexions. The arrangement consists of an outer silver tube, with a funnel-shaped orifice passing friction-tight through a stout sheet of rubber. This sheet of rubber rests upon the abdomen, and is held in position by bandages passing round the body of the patient. The inner end of the silver tube is closed and rounded to avoid the possibility of injury to the bladder by sucking it into the tube. Just above the closed end two pieces are cut out, and it is also perforated by a series of holes so that the urine may pass freely into it from the bladder. Into this silver tube a glass tube is dropped, reaching to the bottom and bent at right angles. This is connected by a rubber tube with the urine flask, which is placed at the same height as the right angle bend of the glass bladder-tube. The rubber tube is as nearly horizontal as possible. The whole apparatus is arranged in a light metal stand.

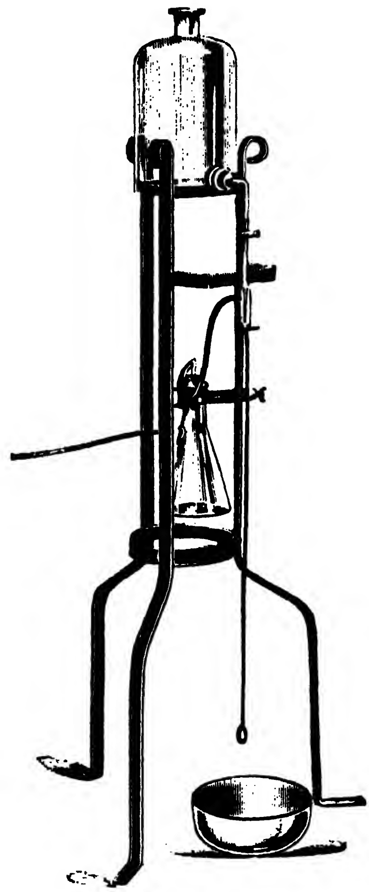


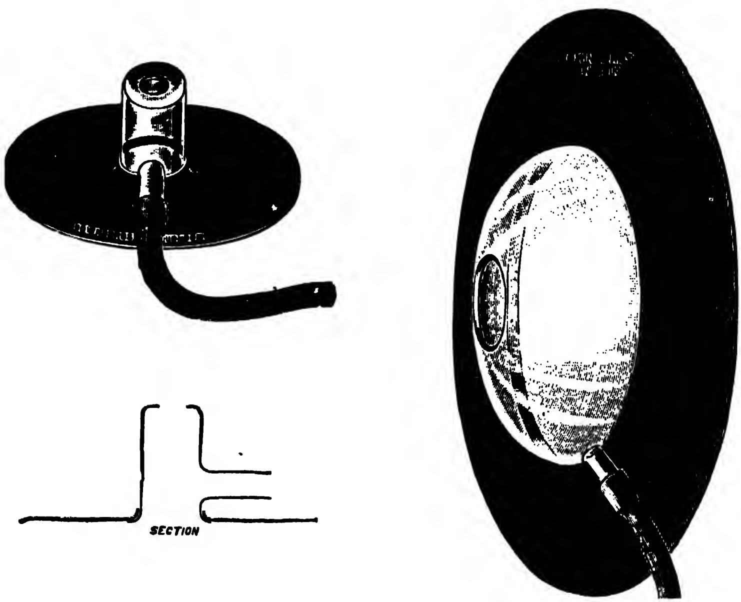
FIG. 218. WHITE'S SUPRAPUBIC EVACUATOR.

These evacuators can be applied only during a short period of time when a drainage tube is retained in the wound. In most cases this amounts to four or five days, after which the tube is removed and the wound encouraged to heal. Where hæmorrhage follows the operation and clotting takes place the action of the suction apparatus is impeded.

2. *Siphonage.* If a small tube has been placed in the bladder this may be connected with a length of rubber tubing and carried to a vessel containing fluid under the bed. This will act as a siphon.

If a large tube has been introduced into the bladder a length of Paul's colotomy tubing may be attached to it, brought through the dressing and allowed to hang over a vessel. A little oil should be run through the tubing to prevent the surfaces adhering.

The siphonage methods are not very reliable. The siphon action is difficult to control, and, as a rule, acts too powerfully, draining the fluid from the bladder very energetically and then sucking in air which interrupts the action. The second method acts probably more as an overflow than as a siphon and is satisfactory in many cases where a large tube is used. The application of these methods is limited in the same way as in the evacuators just described.



A B

FIG. 219. COLT'S APPARATUS. A, Suprapubic dressing, round or cylindrical pattern; B, Suprapubic dressing, oval pattern.

3. *Overflow apparatus.* By means of these instruments the urine is collected as it wells up at the mouth of the suprapubic wound, and conducted into a receiver.

Colt's apparatus. Mr. G. H. Colt has devised an apparatus[1] (see Fig. 219) which consists of (i) a hollow glass cylinder, $\frac{5}{8}$ inch in diameter, with the top partially closed and the bottom turned outwards as a flange. From the cylinder a tube projects at right angles. (ii) A circular disk of rubber, 3 inches in diameter and $\frac{1}{32}$ inch thick. It has a central circular hole $\frac{5}{16}$ inch in diameter, and this fits over the flanged part of the cylinder. The skin of the patient is shaved and cleared of grease for

[1] *Lancet*, November 4, 1905; *Practitioner*, June, 1906.

2 inches round the opening of the fistula. A rubber solution, made by dissolving rubber in naphtha, is applied to the cleansed area of skin, and the under surface of the rubber disk is coated with the same solution.

The apparatus is then applied to the wound, and the rubber lies flat upon and adheres to the skin and the glass cylinder projects vertically from the surface. A rubber drainage tube is attached to the branched tube and is fixed to the skin by a broad band of adhesive plaster midway between the anterior superior iliac spine and the orifice of the fistula. The end of the tube hangs in a receptacle. The open top of the glass is tightly covered with a piece of gauze. The opening is intended to permit the entrance of air and so prevent siphonage, which has been found to suck out the edges of the fistula and prevent healing.

This apparatus is usually efficient for four days. At the end of this time it becomes loose and should be removed or renewed.

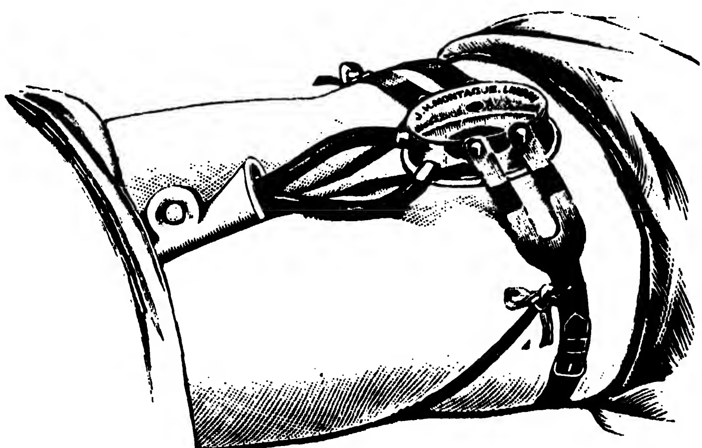


FIG. 220. IRVING'S APPARATUS.

Irving's apparatus.[1] Dr. Hamilton Irving's apparatus (see Fig. 220) consists of a celluloid cap shaped like a straw hat, having a small curved rim and a perforated crown that can be removed like a lid. The cap is fastened in place by means of a strap passing round the abdomen, to the ends of which elastic bands are fixed, and a tendency to slip upwards is counteracted by tapes passing from the lower end round the perineum and tied to loops in the abdominal strap. The elastic bands have eyes which fit over hooks on the celluloid cap. The hooks are attached on a level with the lid, so that the elastic pressure is exerted almost perpendicularly and keeps the rim in contact with the skin all round the wound. The urine escapes by two outlets, one on each side of the lower end of the apparatus, and passes through india-rubber tubing into a suitable urine bottle which rests in the bed between the patient's legs. The lid is easily slipped on and off, and has a hole in the centre which admits easily a No. 24 French catheter.

This apparatus has several advantages over the others described above.

[1] *Lancet*, December 21, 1907.

It may be applied at the close of the operation and retained until the wound is closed. When, however, there is any likelihood of hæmorrhage taking place, the lower end of the bed is raised on blocks for the first twenty-four hours, and the apparatus is not applied until the bed is lowered to the horizontal. The wound is freely accessible by merely removing the lid. The restriction of the patient's movements is reduced to a minimum.

In most patients the apparatus fits well and is worn with comfort. In thin individuals, however, the ring presses upon the prominent pubic symphysis, and if the abdomen is hollow, leakage may take place at each side. The area within the ring becomes somewhat congested and the wound everted, and in some cases I am inclined to believe that healing is delayed.

In the writer's experience suprapubic cystotomy wounds heal best without any apparatus, and healing may be hastened by a catheter retained in the urethra for a few days when granulation of the wound is nearly complete. The patients do not complain greatly of the discomfort of soaked dressings. If they do, and if expense has to be considered, an Irving apparatus should be applied. In cases where it is necessary that no urine should be allowed to remain in the bladder lest it soil a vesical or urethral wound, White's apparatus is the most satisfactory method by which the urine can be removed.

The relative efficiency of suprapubic and perineal drainage of the bladder. It has been universally held that drainage through a perineal wound taps the lowest part of the bladder and that suprapubic drainage fails to do this. The perineal drainage tube enters the bladder through the internal meatus. It is true that in a child standing erect the lowest part of the bladder is the internal meatus. In an adult male standing erect the lowest part of the bladder will be behind this, and when he is lying on his back the lowest part of the bladder is well behind the interureteric bar. A surgeon accustomed to perform litholapaxy recognizes this from the position in which he feels for a stone with the lithotrite. The portion of the perineal drainage tube which projects through the internal sphincter is thus several inches above the lowest part of the bladder. The suprapubic drainage tube passes down as far as the trigone, and the bladder contracts around it. A tunnel is thus formed, at the lower end of which is the posterior part of the trigone and post-trigonal pouch. Suprapubic drainage therefore taps a lower level than does perineal, and if siphonage or suction be applied, the bladder may be kept practically dry.

A further advantage of suprapubic drainage is that a much larger drainage tube can be used, through which washing of the bladder can be performed, and that the suprapubic wound is more easily attended to and kept clean.

PERMANENT SUPRAPUBIC DRAINAGE

Permanent drainage of the bladder may be required for malignant diseases of the prostate or for other conditions.

After suprapubic cystotomy the wound is allowed to contract down to the size of a No. 30 French catheter, and a soft rubber instrument of this

FIG. 221. APPARATUS FOR PERMANENT SUPRAPUBIC DRAINAGE.

size is passed along the fistula into the bladder. Over the surface of the suprapubic scar a silver plate is adjusted, and in the middle of this is fixed a bent silver tube about 2½ inches long (see Fig. 221). The catheter when stretched passes easily through this, but when relaxed fits it securely. The metal plate is strapped on by means of a waist-belt. The catheter is carried into a rubber reservoir strapped to the patient's thigh. A patient can get about in comfort with this apparatus.

CHAPTER IX

OPERATIONS FOR TUMOURS OF THE BLADDER

Before performing an operation upon the bladder for growth a careful examination should be made with the cystoscope, so that an opinion may be formed as to the accessibility of the growth, and its extent and character.

At this preliminary examination the following points should be noted :—

1. The position of the growth in the bladder and its relation to the ureters and internal meatus.
2. The number of growths.
3. Whether the growths are pedunculated or sessile.
4. The character of the surface of the growths, whether fimbriated, raspberry-like, smooth, nodular, or irregular.
5. Evidence of infiltration, ulceration, phosphatic deposit, or necrosis.
6. The presence of cystitis.

I am in the habit, when dealing with multiple papillomata, of making, at the time of the preliminary cystoscopy, a chart of the exact position and size of the villous tumours, and at the operation this is kept before me. When more than one growth is present this is necessary, for it is easy to overlook a small bud of papilloma after several large masses have been removed. It is an easy matter to count and localize a number of papillomata with the cystoscope when the bladder is fully distended, but it is less simple to find them when the bladder is open and collapsed. When the operation has been some time in progress the mucous membrane of the bladder frequently becomes swollen and œdematous and the wall rigid, and this adds to the difficulty of searching for small papillomatous buds when no chart lies before the operator.

FOR NON-MALIGNANT GROWTHS

Excision of the growth with the mucous membrane surrounding its base is the most thorough method.

This is carried out in the following manner: The bladder having been opened above the pubes, a suture of catgut is passed through each

lip of the bladder wound, and the sutures are pulled upwards so as to raise the bladder well into the wound. The patient is now placed in the Trendelenburg position, and the edges of the bladder wound retracted

FIG. 222. AUTHOR'S BLADDER RETRACTOR. The part next the shank retracts the abdominal wall and the cut edge of the bladder-wall by direct horizontal traction. The intravesical part pushes back the bladder-wall by a tilting movement. The traction and tilting are easily obtained by grasping the handle with the thumb directed upwards.

FIG. 223. TOOTHED FORCEPS FOR BLADDER OPERATIONS.

FIG. 224. SCISSORS FOR INTRAVESICAL OPERATIONS.

FIG. 225. FINE NEEDLE FOR SUTURE OF THE BLADDER MUCOUS MEMBRANE.

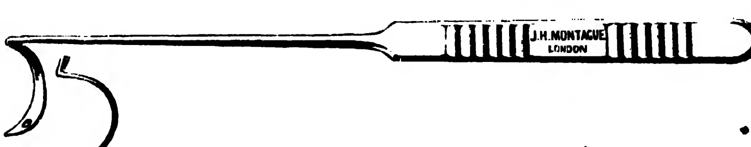


FIG. 226. LARGE NEEDLE FOR SUTURE OF THE BLADDER-WALL.

so as to display the growth (see Fig. 227). Even with the inclined position of the patient there is a tendency for the intestines to push the posterior bladder-wall towards the pubes and so obscure the base of the bladder. This is obviated by tucking a roll of gauze into this part of the bladder and placing a retractor over it at the upper angle of the wound. Another

retractor may be placed on each side, but often a single one at the upper angle will give a good exposure of the tumour. I use retractors of different sizes, which are specially designed to overcome the inward bulging of the posterior and lateral walls, and to give plenty of room for intravesical manipulation (see Fig. 222). For removing the growth the following instruments are useful: Fine toothed forceps, $7\frac{1}{2}$ to 8 inches long, to pick up the mucous membrane (see Fig. 223); long, fine curved, sharp-pointed scissors, not less than 8 inches (see Fig. 224); several pairs of long fine serrated forceps by which small pledgets of gauze or cotton-wool

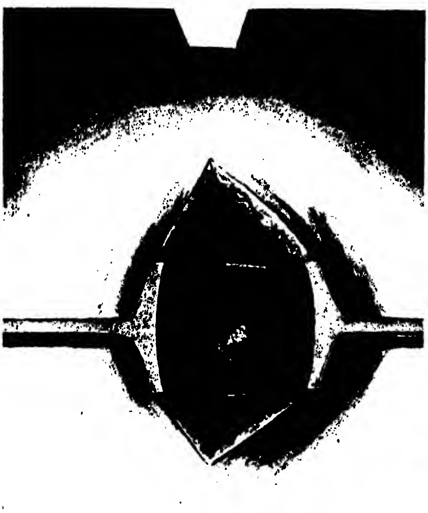


FIG. 227. EXPOSURE OF A PAPILLOMA OF THE BLADDER. The papilloma is situated behind and to the right of the trigone.

FIG. 228. REMOVAL OF A PAPILLOMA OF THE BLADDER. *First stage.* Incision of the mucous membrane.

are applied to the cut surface; a long fine sharp hook to steady the bladder-wall if necessary; several fully curved needles of different sizes with a diameter of one inch and less, set at right angles, right and left, on a fine handle not less than 8 inches long (see Figs. 225, 226); and long fine artery forceps. An electric forehead-lamp should be used.

The mucous membrane of the bladder is picked up just above the base of the tumour and gentle traction made upon it. This raises the area of mucous membrane around the base sufficiently to make it prominent. No attempt should be made to drag the growth and surrounding mucous membrane up into the wound. With the curved scissors the mucous membrane is cut through around the base of the stalk, leaving a narrow

rim of mucous membrane all round, and cutting outside the forceps so that they remain attached to the mucosa of the tumour (see Fig. 228). The mucous membrane retracts and, if the pedicle is fibrous, the firmer fibrous core is exposed. This is clipped through with scissors, cutting well into the muscular tissue in doing so (see Fig. 229). In many of these growths the pedicle is very delicate, and the tumour comes away when the mucous membrane is cut through. A long pair of pressure-forceps is clamped on the bleeding point, and left on for a short time. When they are removed the bleeding has ceased. The wound in the

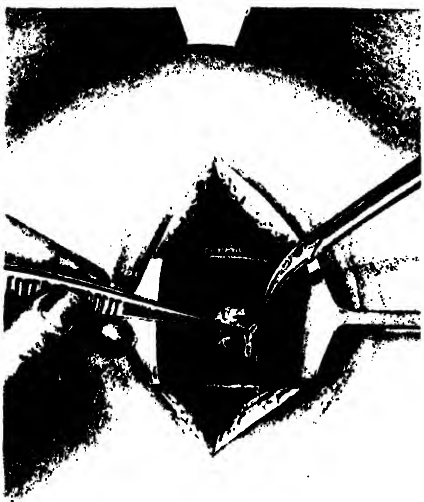


FIG. 229. REMOVAL OF A PAPILLOMA OF THE BLADDER. *Second stage.* Cutting through the pedicle after incision of the mucous membrane.

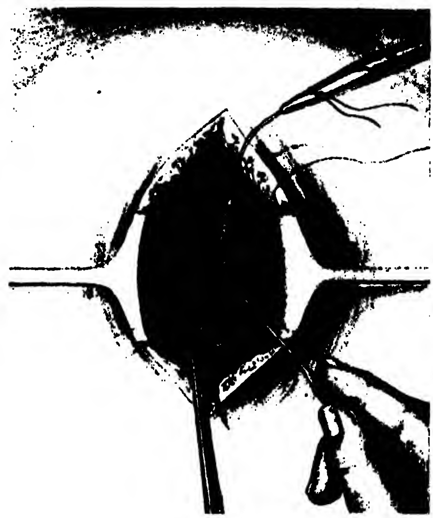


FIG. 230. REMOVAL OF A PAPILLOMA OF THE BLADDER. *Third stage.* Closing the wound in the mucous membrane with interrupted sutures.

mucous membrane is closed with one or two sutures of very fine catgut (see Fig. 230). These should be tied with extreme gentleness lest they tear through the delicate mucous membrane.

A small bud of papilloma may be steadied with forceps and clipped off with curved scissors, removing with it a portion of the adjacent mucous membrane. The edges of the small wound are brought together with a single stitch of fine catgut, or a few touches of a fine electric cautery point will sear the surface and stop the bleeding. The treatment described above is suitable either for pedunculated or sessile papillomata.

When an area of mucous membrane is covered with a number of closely set papillomata it is better to remove the strip of mucous membrane bearing the growths and bring the edges together with interrupted sutures

of fine catgut after clamping any spouting vessels. Occasionally a ligature may be required for a vessel, but usually a short application of pressure-forceps will suffice, and arrest any bleeding.

Another method is to place a clamp upon the base and cut off the tumour with curved scissors close to the clamp. Guyon's clamp (see Fig. 231) is specially constructed for this operation. Several sutures of fine catgut may now be passed through the base of the pedicle on the bladder side of the forceps. The clamp is then cut away with curved scissors, and the catgut stitches tied. If oozing continues between the stitches, one or two additional stitches may be introduced obliquely through the muscular layer and tied. Instead of placing stitches in the base of the tumour, the portion which lies in the grasp of the blades of the clamp may be seared with a fine electric cautery point and the clamp then removed.

FIG. 231. GUYON'S CLAMP FOR BLADDER TUMOURS.

Fenwick uses the following method: A porcelain speculum similar to a Fergusson's vaginal speculum is introduced into the bladder through the suprapubic wound and sunk to the base, against which the rim presses. Within the circle is the papilloma, which is thus shut off from the rest of the bladder. Any fluid in the 'caisson' is removed by gauze plugs, and the tumour is examined with the light of the head-lamp. If it be pedunculated the pedicle is clamped with curved serrated forceps, and the growth cut away and removed from the 'caisson'. The speculum is now removed, and a finer clamp is applied to the base of the pedicle on the bladder side. The first clamp is cut away with the pedicle in its grasp; the second clamp is left on the base for twenty-four hours and then removed. Small sessile papillomata are bitten off with cup-shaped cutting forceps, and the base touched with a dab moistened in perchloride of iron, and the surface pressed for a few seconds with a dry dab.

Oozing from the mucous membrane is sometimes troublesome after any of these methods. It is controlled by washing the bladder through the catheter in the urethra with a copious stream of hot boracic lotion (110° F.). Extract of suprarenal gland may be used to control this type of bleeding. It should be applied directly to the bleeding spot on a pledget of cotton-wool. After such an operation for papilloma the bladder wound may be closed if the surgeon be satisfied that the bleeding

has ceased. This is carried out in the manner described on p. 435, and with the precautions there noted. A large-sized coudé catheter (20, 22) is tied in the urethra, and retained for four or five days.

FOR MALIGNANT GROWTHS.

Sonnenberg[1] was the first to resect a portion of the bladder-wall in its entire thickness.

The extent and method of the operation will vary according to the position and size of the growth, and the operation will therefore be considered according to the position of the growth.

For a growth situated at the upper part of the anterior or lateral walls. The patient is placed in the Trendelenburg position. The bladder is exposed by a vertical incision (see p. 431), and the recti fully retracted. The situation of the growth has been primarily ascertained, and some idea of its extent gained by cystoscopy (see Fig. 232). With the finger the induration of the bladder-wall is now exactly defined. The wall of the bladder is freed from the posterior surface of the pubic bones, and if the bladder has previously been operated upon, tough fibrous adhesions will have to be dissected. The peritoneum is carefully stripped up to the apex of the bladder, and especial care is required in doing this if the operation be a secondary one. The peritoneum should also be stripped frcm the lateral walls of the bladder if the induration be felt to approach one or other side. Having now cleared the whole of the probable field of operation, a vertical incision is made through the bladder-wall well beyond the area of induration on one or other side of it (see Fig. 233). The distending fluid is allowed to escape. A fixation suture of catgut is inserted through each lip of the wound, and includes the whole thickness of the bladder-wall except the mucous membrane. These are clamped with pressure forceps and held up by an assistant. The finger is now introduced into the bladder and the extent of the induration defined on the mucous surface.

FIG. 232. CYSTOSCOPIC VIEW OF A MALIGNANT GROWTH OF THE BLADDER. This growth, after resection of the bladder-wall, is shown in Fig. 237.

The writer adopts the following method for the further steps of the operation: By drawing upon the traction sutures the bladder-wall is pulled well up into the abdominal wound and steadied there. The bladder wound is now extended downwards with blunt-pointed scissors, cutting through the whole thickness of the bladder-wall (see Fig. 234). As the wound extends towards the pubes, a better view of the interior of the bladder is obtained. At each ½ inch a traction suture of catgut is introduced

[1] *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1885.

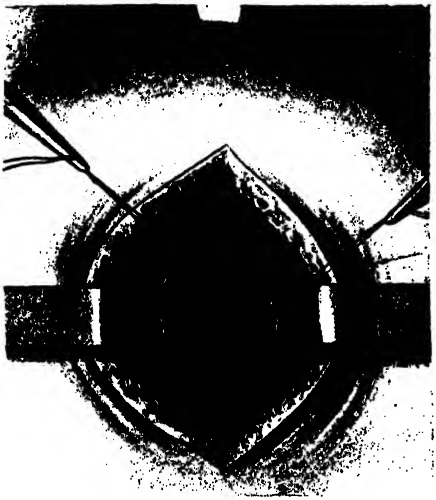


FIG. 233. RESECTION OF THE ANTERIOR BLADDER-WALL. *Showing area of proposed resection.* The inner dotted circle shows the extent of the growth. The larger dotted circle shows the extent of the proposed resection.

FIG. 234. RESECTION OF THE ANTERIOR BLADDER-WALL. *Exposure of the growth.* The incision has been extended and the growth can now be seen. Traction sutures have been inserted.

FIG. 235. RESECTION OF THE ANTERIOR BLADDER-WALL. *Removal of the growth.* The growth-bearing area with a margin has been turned back as a flap. Traction sutures steady the bladder-wall.

FIG. 236. RESECTION OF THE ANTERIOR BLADDER-WALL. *Closure of the bladder-wall.* The growth-bearing area has been removed and the traction sutures are utilized to close the bladder-wall.

through the bladder-wall on the side of the wound opposite the growth. These sutures do not penetrate the mucous membrane. The last one introduced is held up by an assistant to steady the bladder-wall, while the others are clamped and laid in order over the abdomen. Here and there a vessel in the bladder-wall spouts and is picked up in long artery forceps. The incision is carried round the lower end of the growth on the other side towards the apex of the bladder. A large flap of the bladder-wall is thus turned upwards, bearing the growth with a good margin of healthy mucous membrane and muscle all round (see Fig. 235). This flap is now cut away, taking care that the peritoneum has been reflected from the outer surface of this part of the bladder (see Fig. 237). In following the growth upwards to the apex or on to the posterior wall, it may be found impossible to reflect the peritoneum, which is bound down by firm adhesions. In this case the peritoneum must be opened, the edges picked up in forceps, and the cavity packed off. When the growth has been removed, the opening in the peritoneum is closed with a continuous catgut suture. The bladder-wall around the large defect is now supported by a series of traction catgut sutures arranged round the wound. If the patient be collapsed, a drainage tube may be inserted, and those sutures which are opposite are tied together and the bladder thus rapidly closed. If, however, the operation has been well borne, the inner end of each traction suture is threaded in a large curved needle, and passed through the edge of the bladder-wall on the opposite side of the defect, avoiding, as before, the mucous membrane (see Fig. 236). A series of sutures, ¼ inch apart, are thus obtained. The clots are now cleared out of the bladder and a drainage tube placed in the wound towards its lower part, so that the track left after its removal will be oblique. The sutures are now tied off from the apex of the bladder towards the urethra; a second row of Lembert's sutures may be added to this, but where a drain is inserted they are not absolutely necessary. One or two stitches may be passed through the superficial layers of the bladder muscle on each side of the wound and the deep layer of the recti muscles so as to shut off the lateral area of pelvic areolar tissue.

FIG. 237. MALIGNANT GROWTH OF THE BLADDER. Specimen showing part of the bladder resected for removal of growth. Note the margin of healthy mucous membrane and the layers forming the whole thickness of the bladder-wall.

For smaller growths less extensive resection may be required, and the bladder wound may be completely closed and a catheter tied in the urethra.

For growths affecting the upper part of the posterior wall. The patient is placed in the Trendelenburg position, the anterior surface of the bladder exposed, and the peritoneum carefully stripped off the apex and posterior wall of the bladder. If the peritoneum be found adherent over the growth so that it cannot be detached it will be necessary to open the peritoneal cavity. If the growth be readily accessible near the apex of the bladder, this will be done before opening the bladder. The membrane is stripped off as far as possible and then incised and clipped round the edge of the adherent portion with scissors. The rent is now closed with a continuous catgut suture and covered with a large pad. If the growth be situated lower down and be less accessible, the bladder should be emptied and the growth accurately defined before opening the peritoneal cavity. The bladder is incised in the middle line anteriorly near the apex and the distending fluid allowed to escape and carefully mopped up. The finger is introduced into the bladder and the growth defined. With the bladder collapsed the posterior surface can be more easily reached, and the peritoneum is incised at the edge of the adherent area and treated as above. A portion of omentum may adhere to the peritoneal aspect of the growth, and this should be tied and cut adrift.

Having closed the peritoneal wound, the bladder wound should be extended backwards so as to encircle the growth.[1]

The same means of raising and fixing the edges of the wound above described are used. After removal of the growth the traction sutures are pulled up and used to close the wound, working from the apex of the bladder down the posterior wall. A second row of Lembert's sutures is placed over the first. A large drain is inserted in the anterior part of the wound. It is sometimes necessary to incise the inner borders of the recti muscles or to cut one rectus across partly or completely. This is done with the precautions stated on p. 438, and the edges of the severed muscles are carefully united after the operation.

Transverse cystotomy (see p. 437) is seldom necessary.

For growths affecting the base of the bladder or the lower part of the anterior, lateral, or posterior walls with the base. The choice

[1] Bardenheuer (Göcke, *Deut. med. Wochenschr.*, 1897) recommended that if the peritoneum had to be resected the operation should be done in two stages. The peritoneum should be resected and stitched, and after fourteen days, when the peritoneal wound was healed, the removal of the growth should be carried out. This precaution is not, however, necessary, for the peritoneal wound seldom gives rise to any trouble.

of operation in these cases will lie between partial resection and total extirpation of the bladder. When a partial resection has been decided upon, the first care of the surgeon will be to examine the relation of the growth to the ureters. If one or other of these ducts be involved in, or surrounded by, the growth a preliminary operation for the transplantation of the ureter will be necessary. A ureteral catheter is passed along the duct, the peritoneum is stripped from the lateral wall of the bladder until the ureter is reached, and the duct is traced down as far as possible and cut across close to the wall of the bladder. The catheter is now removed and a fine thread of silk passed through the lower end of the ureteral wall. The duct is set aside until the resection of the bladder-wall is completed. The method by which the ureter is implanted in the bladder is discussed elsewhere. If the ureters be free from the growth a ureteral catheter is introduced into the duct on the side on which the bladder is affected. This should be done at a preliminary cystoscopy and the operation performed forthwith. Where this is found impossible, from the position or exuberance of the growth, the catheter should be introduced through the suprapubic wound. It is necessary that the ureter should thus be safeguarded, for otherwise it will be impossible to recognize the intramural portion of the duct during the operation.

A vertical abdominal incision with limited section of the recti muscles will usually suffice to give a good exposure even in stout muscular subjects. Occasionally a transverse incision through the abdominal wall may be considered advisable in a stout patient.

The writer has performed the following transvesical resection of the bladder-wall on several patients and removed the growths completely, with the whole thickness of the muscular wall.

Having exposed and incised the bladder, the anterior wall should be examined, and if a contact ulcer is present this should be excised by extending the incision round it. The main growth is now examined and fully exposed by a bladder retractor on the side opposite to the growth, and a large roll of gauze is tucked into the posterior wall and another retractor placed over it. A powerful head-lamp is necessary, and two assistants are useful, one to retract and one to sponge. The sponges are small plugs of sterilized gauze on long forceps. The mucous membrane of the bladder is seized with long forceps about ½ inch beyond the edge of the growth and cut through with long curved sharp-pointed scissors, and this incision is carried downwards along the anterior aspect of the growth, keeping ½ inch beyond the margin of the growth. The incision is then carried along the posterior aspect of the growth, having a similar margin of healthy mucous membrane. The

bleeding is not severe. One or two vessels are picked up in long pressure forceps, which are left on for a few minutes.

The wound is now deepened through the muscular substance, commencing above and working downwards along the anterior and then along the posterior aspect and picking up any vessels that spout. The upper end of the growth, together with the whole thickness of the muscular bed on which it is implanted, is thus freed, and may now be grasped with volsella forceps and gradually raised as the dissection proceeds (see Fig. 238). The point of the left forefinger is pushed under the tumour and detects strands of tissue that hold it down and vessels that pass into it. Curved blunt-pointed scissors keep in touch with the pulp of the finger and cut through the bands that hold the tumour down. The upper end of the flap, consisting of the tumour and the whole thickness of the bladder-wall, is gradually raised up, and the incision in the mucous membrane is now carried round the base and marks out the whole area to be removed. The growth is pulled backwards and the bladder muscle cut through along the anterior surface and round its inner end until the whole mass can be raised and turned back, and the section of the muscle on the posterior aspect of the tumour completed by cutting from below. Having carried this through to the incision in the mucous membrane, the whole mass is removed.

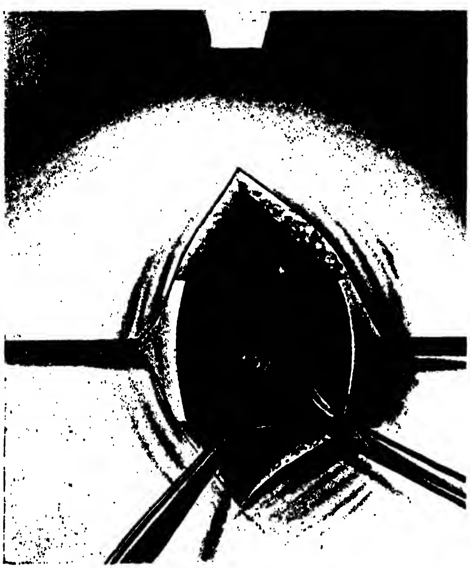


FIG. 238. TRANSVESICAL RESECTION OF THE BLADDER-WALL. *First stage.* The whole thickness of the bladder-wall has been cut through above the growth. A flap, consisting of mucous membrane, bladder muscle, and perivesical fat, is held up with forceps while the wound is extended with curved scissors. A ureteral catheter lies in the right ureter.

Any bleeding from the bladder-wall is now stopped, and one or two catgut ligatures may be required. In the floor of the bladder wound will be found the perivesical areolar tissue and fat and sometimes the upper part of the prostate. At the stage when the flap is being raised, some veins of the lateral part of the vesico-prostatic plexus may be torn

or cut across and a troublesome venous bleeding take place. A strip of gauze should be packed under the mass as the operation progresses and tucked in with forceps. When the growth has been detached the packing is removed and bleeding will probably have ceased. Any points that still bleed should be picked up in long pressure forceps and catgut ligatures applied. If resection of the ureter has been necessary, the silk suture which was passed through the lower end of the duct is now threaded on an aneurysm needle and passed through the wound in the bladder-wall. The ureter is drawn through at the upper angle of the wound; the end is trimmed, cut obliquely, and stitched to the

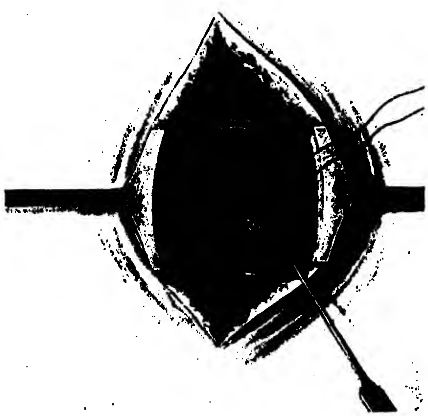


Fig. 239. Transvesical Resection of the Bladder-wall. *Second stage.* Closing the wound in the bladder muscle with interrupted sutures.

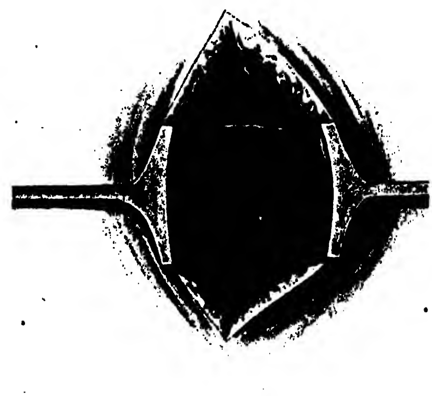


Fig. 240. Transvesical Resection of the Bladder-wall. *Third stage.* The mucous membrane has been united with interrupted catgut sutures.

mucous membrane and muscles. If the ureter be too short to reach to the wound, it will have to be implanted into another part of the bladder wall. With a fully-curved needle set on a long holder, the bladder muscle on each side of this irregular wound is now united by a number of interrupted sutures (see Fig. 239), commencing at the highest end of the wound and leaving each suture long, so that by gentle traction upon it the next part of the wound will be brought up ready for the next suture. Over this the mucous membrane should be united, using fine catgut and small curved needles and avoiding stripping up and tearing the delicate mucous membrane (see Fig. 240). The ureteral catheter is withdrawn.

All packing and swabs are now removed from the interior of the

bladder, which is flooded with a stream of hot boric lotion passed through a catheter in the urethra. A large drainage tube (1 inch in diameter) is placed in the bladder and the wall closed around this. The abdominal wound is treated in the manner described on p. 435.

After-treatment. For the first twenty-four hours the patient should lie on the side opposite to that from which the growth was removed, so as to prevent, as much as possible, soaking of the wound with urine.

After this time a White's suprapubic evacuator (see p. 444) should be adjusted and the bladder drained for a week.

Either once or twice a day, according to the state of the urine, the bladder is flushed through the large suprapubic tube with several pints of weak, unirritating, antiseptic solution (biniodide of mercury, 1 in 15,000). At the end of a week the evacuation apparatus and tube are removed and a large-sized coudé catheter tied in the urethra for eight or ten days.

For a circumscribed growth surrounding the ureteral orifice. The following operation is described by Albarran[1]:—

Transverse cystotomy is performed, and if possible a catheter passed into the ureter. An incision is made with a bistoury through the mucous membrane around the growth, including the ureteric opening. The growth is seized with forceps and the incision deepened with sharp-pointed scissors through the muscular wall of the bladder. The ureter should be included in the muscular tissue, and by dissection with the finger a pedicle is formed by the ureter. An incision is now made through the wall of the ureter beyond the growth and a fine thread of catgut is passed through it. The ureter is then cut across completely and another suture passed through the wall opposite the first. The resection of the portion of the bladder-wall which bears the growth is now completed. The ureter is now drawn into the bladder by means of the two threads of fine catgut. With fine scissors the ureter is split so as to form right and left flaps. The threads of catgut are now passed through the whole thickness of the bladder-wall on each side of the lower end of the wound and tied. The remaining part of the vesical wound is closed with catgut sutures.

When it is impossible to find the orifice of the ureter and pass a catheter into it, a search for the ureter should be made after the growth has been removed, and it may be found in the perivesical fat. If it cannot be found, the part of the bladder wound at which the opening would naturally lie is left open. In one case in which this was done Albarran states that the patient made a good recovery, and an infundibuliform orifice discharging the urine could afterwards be

[1] *Médecine opératoire des voies urinaires*, 1909.

seen with the cystoscope. If in such a case the ureter becomes narrowed so as to cause renal retention, a uretero-cystotomy can be practised.

Results. **Mortality.** The immediate result of operation upon tumours of the bladder varies according to the character of the growth and the nature and extent of the operation which was performed.

By combining his own collection of cases [1] with that of Rafin [2] Watson obtained [3] 679 cases of operation upon tumours of the bladder. Of these 319 were for benign tumours, 334 for malignant tumours, and 26 for 'special varieties of neoplasms' (myxoma and cholesteatoma).

Suprapubic operations without resection of the bladder-wall were done in 319 benign tumours with a mortality of 11·0%. Of 334 malignant tumours operated upon there were 279 cases of carcinoma, of which 70 died, a mortality of 35%, and 55 cases of sarcoma, 23 of which died, a mortality of 43%. There were 4 deaths in 16 operations for myxoma (25%), and 1 death in 10 operations for cholesteatoma (10%).

Partial resection of the bladder in 96 cases of carcinoma resulted in 21 deaths (21·8%).

After-results. In 165 suprapubic operations without resection there was recurrence in 28·4% and non-recurrence after three years of just under 20% of benign tumours.

In 125 cases of malignant disease operated on by the suprapubic route without resection, 65% had recurrence within three years. In 4·8% there was no recurrence.

In 50 cases of partial resection of the bladder for carcinoma there was recurrence in 58% within three years, and 10% were free from recurrence.

[1] *Annals of Surgery*, December, 1905, No. 6.

[2] *Rapp. et Informat. XIe Session de l'Assoc. Franç. d'Urologie.* Paris, October, 1905.

[3] *Diseases and Surgery of the Genito-urinary System*, 1909.

CHAPTER X

CYSTECTOMY

GENERAL CONSIDERATIONS

Indications. Complete removal of the bladder has been performed in a few cases for very extensive development of papilloma, and in one case of tuberculosis and one of vesico-vaginal fistula.

The only indication that need be discussed, however, is malignant disease of the bladder. Before the question of cystectomy can be entertained, certain conditions must be fulfilled.

(1) The patient must have sufficient strength to undergo a very severe operation.

In the later stages of malignant disease of the bladder ascending pyelonephritis is a frequent complication. In other cases ureteral obstruction causes hydro- or pyonephritis. Failure of the renal function is likely to follow a severe operation in such cases.[1] Apart from renal complications death from exhaustion very frequently follows cystectomy if the patient be weak and cachectic.

(2) The growth must be confined to the bladder, *i.e.* there must be no sign of local spread beyond the bladder, and no evidence of metastatic deposit in glands and other organs. An exception to this restriction may be made in favour of the prostate, where cysto-prostatectomy is to be performed.

Choice of operation. The malignant growths that are confined to the bladder may be removed either by resection of a part of the bladder-wall or by removal of the whole bladder, and it will be necessary to choose between these two operations.

It is possible to remove completely a circumscribed malignant growth of the bladder by resection of the wall when the growth is situated at any part except on the trigone. Even where the growth has invaded the ureter on one side the duct may be transplanted to another part of the bladder and the infiltrated portion removed with the rest of the growth. Where, however, both ureters are involved and the base is infiltrated, resection of the bladder-wall will not suffice to remove the whole growth,

[1] Author, *Renal Function in Urinary Surgery*, 1908.

and cystectomy must be performed. The same applies to cases where the growth has spread over a large area of the bladder-wall.

Wherever it is possible, resection of the bladder-wall should be preferred to cystectomy, for the former carries an operative mortality of 22% (Enderlein and Walbaum[1]), while the latter operation is fatal in 61·5% of cases (Goldenberg[2]). With the increased accuracy of diagnosis by means of the cystoscope, bladder growths are discovered and their nature recognized at an earlier stage than hitherto. The cases suitable for resection will therefore proportionally increase in the future. Cystectomy should be reserved for the cases where resection of the bladder-wall is impossible.

Another point that will have to be decided before operation is whether the prostate and seminal vesicles should be removed with the bladder. When these organs are not actually invaded by the growth they may, according to some authorities, be left untouched. The operation of cysto-prostatectomy, when performed by the combined perineo-abdominal method, is not more difficult and does not seem to be more fatal than the removal of the bladder alone, and it possesses the great advantage of removing the prostate, which is very intimately connected with the bladder base and is frequently invaded by bladder growths in this region.

Treatment of the ureters. The efficient derivation of the urine is the most difficult problem which has to be faced in cystectomy. The dangers of this part of the operation are immediate and remote. The immediate dangers are shock and collapse from an operation prolonged by implantation of the ureters. The remote dangers are ascending septic inflammation of the kidneys, which is specially frequent where the implantation has been made into the bowel, and kinking of the ureters and stenosis of the new ureteral orifice in any implantation. The state of the patient at the end of the cystectomy in some cases has necessitated abandoning the ureters in the depth of the wound or fixing them in the suprapubic wound, and a few patients have recovered.

Watson[3] regards five out of fifteen deaths in twenty-five cases of cystectomy as directly due to ureteral implantation. He suggested the separation of the operation of derivation of the urine from that of removal of the bladder, and the use of nephrostomy as the means of draining the urine. Other surgeons have substituted ureterostomy in the two-stage operation.

The following figures show the results of operation in each of the methods :—

[1] *Festschrift z. 60. Geburtstage O. Ballinger's*, Wiesbaden, 1903.
[2] *Beitr. z. klin. Chir.*, vol. xliv, 1904.
[3] *Annals of Surgery*, vol. xlii, December, 1905.

I. **Derivation of urine and removal of bladder at one operation.** (1) *Ureters abandoned in the wound.* In 4 cases in which this occurred (Bardenheuer, Kümmell, McCosh 2), 2 died, one from shock and another from uræmia, and 2 recovered and were well thirteen and fifteen months respectively after the operation.

(2) *Ureters fixed in the suprapubic wound.* In 6 cases (Wasilief, Harris, Woolsey [1 ureter in rectum], Bardenheuer 2, and Garre), 2 recovered from the operation, and 4 died. One patient died of shock and another of uræmia. One died two months after the operation from pneumonia, and another after an attempt to transplant the ureter from the wound into the urethra, while a third died of uræmia after several attempts had been made by plastic operations to create a new bladder. None of these deaths appear to be fairly attributable to the actual seat or method of implantation.

(3) *Implantation of ureters in the rectum.* In 13 cases of implantation of the ureters in the rectum after cystectomy for growths of the bladder, 8 died (Küster, Giordano, Turetta, Schede, Lund, Wendel, Wiljaminew, Krause), and 5 survived the operation (Tuffier, Chalot, Winiwarter, Krause, Carson). The deaths were due to shock from prolonged operation, 3; exacerbation of previously existing pyelitis, 1; ascending infection, 4. It will be seen here that about one-half of the deaths resulted from the extreme length of the operation, and the other half from ascending infection from the rectum. Of the patients that recovered, 1 died from unknown causes fourteen months after the operation (Tuffier), 1 had recently been operated on when the record was published (Carson), 1 was in good health three and a half months after the operation (Krause), and 1 was in good health and comparative comfort five years after the operation (Winiwarter). In none of these cases, however, was the implantation into the rectum successful, for a fistula formed and the urine passed by this.

(4) *Implantation of the ureters into the large intestine.* In a case of papilloma vesicæ, where Wilms[1] performed cystectomy, he successfully implanted the ureters in the sigmoid flexure of the colon. Six months after the operation, the patient voluntarily passed urine from the rectum every two or three hours, and once or twice at night.

Krönig[2] performed lumbar colotomy, and later removed a cancerous uterus and bladder and implanted the ureters in the rectum. Four months later the urine was clear.

After cystectomy Verhoogen[3] isolated the cæcum and implanted the

[1] Recorded by Jaeger, *Inaug. Diss.*, Leipzig, 1906.
[2] Quoted by Albarran, *loc. cit.*
[3] *Centralbl. f. d. Krankh. der Harn- u. sex. Org.*, 1895, vol. vi.

ureters into it, making an opening at the abdominal wound. Two patients on whom he operated in this manner died.

Albarran[1] quotes 6 fatal cases and 2 recoveries from implantation of the ureters in the large intestine by various surgeons.

(5) *Implantation of the ureters into the urethra.* Stimulated by Sonnenberg's[2] successful operation in ectopia vesicæ, several surgeons have attempted to implant the ureters in the urethra after cystectomy.

In 4 cases (Kayser, Lindner, Göpel, Bardenheuer), 3 died after the operation from shock, and the fourth from pyelonephritis, after an attempt to transplant the ureters from the abdominal wound into the urethra.

(6) *Implantation of the ureters in the vagina.* Of 7 cases where this operation was performed (Pawlik, Kossinski, Robson, Zeller, Mann 2, Lapthorne Smith), 3 died and 4 recovered. Shock accounted for 2 deaths, and ascending pyelonephritis for the third.

In Pawlik's[3] patient the vagina was converted into a receptacle which held 300 cubic centimetres of urine. The urethra was implanted in this, and voluntary micturition was established. The patient was well sixteen years after operation. In the other cases the functional result was not so fortunate, for no reservoir was formed and the urine leaked from the vagina.

II. **Derivation of the urine and removal of the bladder in two stages.** (1) *Implantation of the ureters in a wound in the loin.* In six cases of cystectomy for malignant disease the ureters were previously brought out on the loin and a permanent fistula established on each side (Albarran 1, Fenwick 2, Rovsing 3). All six patients recovered from the operation.

In one of Rovsing's[4] cases stenosis of the external orifice of the fistula occurred, and the same condition resulted in Albarran's[5] case and necessitated nephrectomy. One of Fenwick's[6] cases was well six months after the operation, and the second was a recent operation. The result in Rovsing's remaining cases is not stated.

(2) *Bilateral nephrostomy.* This operation was suggested by Watson,[7] who claimed that ureteral implantation performed for any reason had a mortality of 41·2 %, and that 44·6 % of the fatal cases were due to the ureteral implantation. If Maydl's operation of transplanting the bladder trigone with the ureters be excluded, as it cannot be done in growths of

[1] *Méd. opératoire des voies urinaires*, 1909.
[2] *Verhandl. d. Deutsch. Gesellsch. f. Chir.*, 1885.
[3] *Wien. med. Wochensch.*, November 7, 1891.
[4] *Centralbl. f. Chir.*, 1907, No. 30, p. 873.
[5] *Loc. cit.*
[6] *Brit. Med. Journ.*, July 4, 1908.
[7] *Annals of Surgery*, vol. xlii, December, 1905.

the bladder, the operative mortality rose to 50%, and half of the fatal cases were directly due to the ureteral implantation.

In 979 cases of nephrostomy, on the other hand, performed for various causes, the mortality was 15%, and the mortality in these cases was due to the disease for which the operation was done, and not to the actual operation.

Further, the fistulæ have been borne by patients for three, seven, and sixteen years without infection of the kidneys, and the patient is able by the aid of an easily adjusted apparatus to exist in comfort.

An interval of four to six weeks should elapse between the derivation of the urine and the removal of the bladder.

The following statements may be permitted in review of this difficult problem:—

1. A large part of the high operative mortality of cystectomy is due to the operation for derivation of the urine being performed at the same time as the removal of the bladder.

2. This part of the mortality is set aside if the two operations are performed separately with an interval of some weeks.

3. The methods of derivation of the urine which are specially suited for the two-stage operation in the male are lumbar nephrostomy and ureterostomy, and in the female subject vaginal implantation also.

4. When the complete operation is performed at one time, the best results have been obtained in female subjects from implantation of the ureters into the vagina.

5. Implantation of the ureters into the rectum is seldom successful, and in the majority of cases where the patient has survived the operation a fistula has formed by which the urine was discharged on the surface and not into the rectum.

6. Implantation of the ureters into the large intestine has not given encouraging results.

7. In surviving cases of implantation of the ureters into the bowel there is very grave danger of ascending septic inflammation.

8. Implantation of the ureters into the urethra has not given good results.

9. Fixation of the ureters in the suprapubic wound has been successful in several cases.

10. After ureterostomy there is considerable danger of stenosis of the outlet of the fistula, and of ascending septic inflammation.

The operation that is most likely to be successful is a two-stage operation, in which the first stage consists in derivation of the urine by vaginal implantation in the female and nephrostomy or ureterostomy in the male subject.

The second stage consists in the removal of the bladder, and if necessary the prostate and seminal vesicles.

The following operations will be described :—

(i) Cystectomy in the male.
(ii) Cysto-prostatectomy.
(iii) Cystectomy in the female.

CYSTECTOMY IN THE MALE

From four to six weeks previous to removal of the bladder some method of derivation of the urine should be carried out (see p. 467).

The combined perineo-abdominal method. The bladder is distended with ten or twelve ounces of fluid, and the pubic and perineal regions are prepared for operation.

The patient is placed in the lithotomy position, and a curved, transverse prerectal incision with the concavity forwards is made. A dissection similar to Zuckerkandl's method of exposing the posterior surface of the prostate for prostatectomy is carried out. The urethro-rectal muscle is cut across, and the space between the rectum and membranous urethra and prostate opened up. The separation is carried as high as possible, stripping the peritoneum off the seminal vesicles.

The extra-peritoneal method. The patient is now returned to the horizontal and then raised into the Trendelenburg position. A transverse suprapubic incision is made as for transverse cystotomy (see p. 437) and the bladder fully exposed.

If a suprapubic fistula be present from a previous cystotomy, this is dissected out, and the bladder explored to ascertain the extent of the growth. The cavity is then packed with gauze and the opening closed with forceps.

If no fistula exists Albarran recommends that the bladder should not be opened, as it is likely to infect the wound.

The peritoneum is now stripped up by blunt dissection to the apex of the bladder, and the separation continued along the posterior wall, using the fingers to peel the membrane off the distended organ.

If the peritoneum be found adherent at any spot so that it cannot be separated from the bladder-wall, it is incised and the wound extended with scissors round the adherent area. The omentum may be found adherent to the bladder, and a portion must be ligatured and cut away. The edges of the wound in the peritoneum are united with interrupted catgut sutures, and the stripping of the peritoneum recommenced. The separation is continued downwards until it meets the dissection which was made from the perineum. The vas deferens is separated from the

wall of the bladder on each side, and the seminal vesicles detached and pushed backwards. The whole bladder is now dragged over to the left, and the right ureter and the large vessels which pass outwards below it to the side wall of the pelvis are isolated. The ureter is separated, ligatured, and cut across, the cut end being seared, as Albarran recommends, with the thermo-cautery. The vessels are clamped.

The bladder is now raised and turned over to the opposite side of the wound, and the remaining ureter and vessels on the right side are treated in the same manner.

The bladder is emptied of the distending fluid, if this has not been previously done, and the apex is seized with forceps and dragged upwards and backwards so as to expose the anterior surface of the union with the prostate.

Albarran recommends that forceps should be passed through the perineal wound from the perineum and the apex of the bladder seized and pulled backwards as if to drag it out of the perineal wound. The pubo-vesical bands are thus made tense, and are cut across.

Dissection is now carried transversely at the front of the base of the prostate where it joins the bladder, and the neck of the bladder where it joins the prostatic urethra is cut across. Tuffier advised the use of the thermo-cautery for this part of the procedure, and seared the mucous membrane of the prostatic urethra in order to reduce the danger of infection from the septic bladder. A clamp is placed on the opening in the bladder. The trigone is dissected off the upper surface of the prostate and removed.

The surgeon now returns to the lateral pedicles which were clamped and set aside; each is ligatured with a single ligature, or the vessels are dissected and ligatured separately. A large rubber tube is placed in the suprapubic wound and another in the perineum.

The abdominal wound is carefully closed (see p. 438).

The intraperitoneal method. Wilms and others have opened the peritoneum transversely at the apex of the bladder without attempting to strip the membrane up. Watson claimed that much greater thoroughness is ensured by the exposure of the bladder in this way. He suggested that the peritoneum should be opened transversely at the apex of the bladder, and that the peritoneum lying upon the posterior surface of the bladder should be incised in its whole length and dissected up until the ureters are reached. If any part of the peritoneum be involved in the process it should be left adherent to the bladder. At the end of the operation the peritoneal wound is closed.

CYSTO-PROSTATECTOMY

Preliminary derivation of the urine is performed as in cystectomy.

The bladder is distended with fluid and the patient placed in the lithotomy position. A curved prerectal incision is made as if for perineal prostatectomy.

The prostate is now completely separated as if for extirpation of the whole prostate and its sheath.

The membranous urethra is cut across at the apex of the prostate and the anterior surface of the prostate separated from the back of the pubic bones.

The patient is now placed in the Trendelenburg position, and the bladder exposed by a transverse suprapubic incision. The peritoneum is stripped off the bladder as described in cystectomy, and the ureters and vessels ligatured on either side. The dissection which was made from the perineum is now reached. The bladder is drawn upwards and backwards, and the pubo-vesical ligaments are cut across. The bladder and prostate are now free, and are removed through the suprapubic opening.

Suprapubic and perineal drainage are established, and the abdominal wall carefully repaired.

VARIATIONS IN THE METHODS OF PERFORMING CYSTECTOMY AND CYSTO-PROSTATECTOMY

The combined suprapubic and perineal operation was first used by Küster[1], and has been adopted by Göpel,[2] Wendel,[3] Watson, Albarran, and others. Removal of the bladder alone or the bladder and prostate has been carried out by many surgeons by the suprapubic route alone.

Rovsing uses the suprapubic route and dissects down behind the bladder, and then behind the prostate, in performing cysto-prostatectomy.

A vertical suprapubic incision with partial section of the recti muscles has been used by some surgeons. Carson[4] made a vertical incision and detached the right rectus muscle from the pubic bone. A transverse suprapubic incision with a vertical incision in the middle line was used by Tuffier[5] and Wilms.

Albarran[6] and Hogge[7] performed symphysiotomy in order to obtain more space. In regard to this procedure, Albarran says that it has the disadvantage of necessitating a buried metal suture in a wound which is liable to be infected, a strong binder is necessary, and there is a danger of

[1] *Volkmann's Sammlung*, 1886, p. 2335.
[2] *Schmidt's Jahrbücher*, 1898. [3] *Beitr. z. klin. Chir.*, 1898.
[4] *Trans. Amer. Surg. Assoc.*, 1905, vol. xxiii, p. 269.
[5] *Rev. de Chir.*, 1898, p. 277. [6] *Les tumeurs de la vessie*, 1891.
[7] *Annales des maladies des organes génito-urinaires*, 1902, p. 375.

non-union of the pubic bones. Küster, Turetta, Schuchardt, and others made a partial resection of the pubic bones (see p. 440), but this gives less room.

Where cystectomy alone is performed, some variations in the method of removing the bladder from the prostate and urethra have been practised. Watson suggested that if the prostate and vesicles were healthy, the bladder should be cut across transversely between two ligatures, and the divided edges of the lower portion might be sutured over the base of the prostate. Tuffier recommended the section of the vesical neck over a curved clamp on account of the possibility of trouble with venous hæmorrhage. Rovsing follows this method and leaves the clamp in place.

These methods ignore the fact that cystectomy is performed in most cases for a growth which is situated at the base of the bladder, and some portion of the growth is likely to be left behind with the trigone.

CYSTECTOMY IN THE FEMALE

An operation similar to that described for the male subject may be done, a vaginal incision replacing the perineal.

Pawlik[1] performed the following operation on a woman aged fifty-seven:

He introduced a metal sound into each ureter, and exposed the ducts in the anterior wall of the vagina. An incision 1 centimetre long was made in each ureter, and the edges of the wound stitched to the upper part of the incision in the vagina. The ureters were cut across below this. A catheter was placed in each ureter, and retained for several days. The openings of the ureters in the vagina were kept dilated by the passage of fine bougies.

Twenty-four days later the bladder was distended with fluid and exposed by a vertical suprapubic incision, and the peritoneum stripped off the posterior surface, the dissection being carried as far as the urethra. The fluid was withdrawn from the bladder, and the suprapubic wound packed.

A vaginal incision was then made immediately above the urethra, and the bladder, which had previously been isolated through the suprapubic wound, was delivered into the vagina. The deepest part of the urethra was then cut across and the bladder completely removed through the vagina. Catheters were placed in the ureters and brought out of the urethra, and the cut end of the urethra was sutured so that the anterior wall was attached to the anterior wall of the vagina and the posterior wall to the posterior wall of the vagina. The vagina was thus made to replace the bladder. The outlet of the vagina was closed by a second operation, and the new reservoir held 400 cubic centimetres, and could be spontaneously emptied by contraction of the perineal muscles.

[1] *Wien. med. Wochenschr.*, Nov. 7, 1891.

Results. Jaeger[1] collected 31 cases of cystectomy, but 2 of them (Nos. 21 and 28) appear to be different reports of the same case, and one is therefore omitted here.

To the 30 cases thus left there may be added those of Schede,[2] Woolsey,[3] Kayser,[4] McCosh,[5] Tully Vaughan,[6] Fenwick 2,[7] and Carson,[8] 39 cases in all. Of these 22 were male and 12 female, and in 5 the sex was not stated.

Death followed immediately or soon after the operation in 18 cases, and 21 survived. The operation mortality was thus 46·1 %.

Of the fatal cases 6 were stated to be due to shock and collapse, and most of them may fairly be attributed to the length of the operation due to the time taken in implanting the ureters in the bowel or elsewhere. With the two-stage operation suggested by Watson a large proportion, if not all, of this part of the mortality figures may be set aside. Disease of the kidneys was the cause of 6 deaths. In 3 of these the patient died of uræmia, which immediately followed the operation, and was probably due to pre-existing disease of the kidneys. In one case where suppurative pyelitis led to a fatal result, the renal disease was present before the operation. Ascending inflammation of the kidneys following immediately on the operation was the cause of death in 2 cases. One patient died of pneumonia.

In 4 of the fatal cases metastatic deposits were found in the abdominal glands, kidneys, lungs, or elsewhere, so that the patient could not have long survived had he recovered from the operation.

Twenty-one patients survived the operation, but one patient (Bardenheuer) died from the effects of a second operation performed eight days later with the object of transplanting the ureters from the skin wound into the rectum. Another (Woolsey) died three and a half months after the cystectomy from ascending infection of the kidneys. Another (Tuffier) died fourteen months after operation from unknown causes, and a fourth died thirteen months after the operation from uræmia which resulted from double pyonephrosis.

Of the remaining 17 cases I could obtain no further information in regard to 5 (Bursa,[9] Wendelenburg,[10] Modlinski,[11] Mann 2[12]), and 2 (Fenwick, Carson) were still under treatment at the time of publication.

[1] *Loc. cit.* [2] *Annales des maladies des organes génito-urinaires*, 1903.
[3] *Annals of Surgery*, 1903, vol. xxxviii, p. 445.
[4] *Hygiea*, Stockholm, 1903, 362.
[5] Quoted by Watson, *Annals of Surgery*, vol. xlii, December, 1905.
[6] Quoted by Watson, *loc. cit.* [7] *Loc. cit.* [8] *Loc. cit.*
[9] *Thèse de Paris*, 1896. [10] *Centralbl. f. Chir.*, 1895, p. 117.
[11] *Berichte über die Verhandl. der deutsch. Gesellsch. f. Chir.*, 1899, p. 143.
[12] *Buffalo Med. Journ.*, July, 1901.

The following table shows the condition of the remaining 10 cases reported at varying periods after the operation :—

No.	*Operator.*	*Time since operation.*	*Ureter implantation.*	*State when last reported.*
1	Kümmel[1] (vesico-vaginal fistula)	?	Rectum	Retains urine in rectum 4 hours.
2	Krause[2]	$3\frac{1}{2}$ months	Sigmoid flexure	Good health. Holds urine 5–6 hours.
3	Wilms	6 months	Sigmoid flexure	Holds urine 2–3 hours.
4	Fenwick	6 months	Skin of loin	Well. Wears apparatus.
5	Wassiljew[3]	7 months	Suprapubic wound	Well. Apparatus.
6	Hartley[4] (tuberculosis)	7 months	Rectum	Well. Holds urine 3–4 hours during day and passes it once or twice at night.
7	McCosh	13 months	Abandoned in wound. Suprapubic fistula.	Well. Leads active life.
8	McCosh	15 months	Abandoned in wound. Suprapubic fistula.	Well. Leads active life.
9	Hogge	5 years	Rectum, perineal fistula formed, one ureter successfully transplanted into rectum a year later.	Well. Perineal fistula.
10	Pawlik	16 years	Vagina	Continent. Voluntary evacuation of 300 c.c. of urine.

In reviewing these results it will be seen that the selection of patients for the operation was not always fortunate, for in a certain number metastatic deposits had already formed, and in others the kidneys were so far diseased as to be the cause of a fatal result. The large mortality due to prolonged operation at one sitting will in the future be much reduced by the two-stage operation. The danger of ascending pyelonephritis is less in vaginal implantation than in implantation of the ureters into the bowel. A fistula of the ureter or renal pelvis on the surface of the body, whether perineal, suprapubic, or on the loin, has shown less danger from ascending septic inflammation than one opening into the bowel.

In only two of the surviving cases (Hogge and Pawlik) has sufficient time elapsed to permit of their being regarded as cures of malignant disease, and as having escaped for a reasonably long time the danger of ascending inflammation of the kidneys.

[1] *Berl. Klinik*, H. 59, 1893.
[2] *Deutsche med. Wochenschr.*, 1900, M 12.
[3] *Russki. Chirurg. Archiv*, 1895, H. 4.
[4] *Medicine*, 1903, vol. lxxxiii, p. 385.

CHAPTER XI

OPERATIONS FOR ECTOPIA VESICÆ

A LARGE number of operations have been suggested and practised for ectopia vesicæ. The following are the chief types :—

I. The formation of a reservoir in the body.
  A. The bladder.
    1. Closure of the defect by osteoplastic operations.
    2. Closure of the defect by flaps.
      (*a*) Autoplastic methods.
        (i) Of skin.
        (ii) Of intestine.
      (*b*) Heteroplastic methods.
  B. Rectum.
    1. By transplantation of ureters.
    2. By vesico-rectal fistula.
  C. Sigmoid flexure.
  D. Vagina.

II. No reservoir formed in the body.
    1. Implantation of ureters.
      (*a*) In urethra.
      (*b*) In skin.
    2. Nephrostomy.

Trendelenburg's operation.[1] This consists in opening the sacro-iliac synchondrosis, which allows of the approximation of the separated pubic bones, and subsequent closing of the defect in the bladder-wall.

The patient is placed in the prone position and a longitudinal incision made over one sacro-iliac synchondrosis. The posterior ligaments of the synchondrosis are cut through and lateral pressure applied to the iliac bone. This ruptures the deeper fibres and allows the pubic bone to swing towards the middle line. A similar operation is performed on the opposite side. The patient is placed on a special couch. Round the pelvis is passed a leather girdle, the ends of which cross in front, and are attached to cords and weights acting over pulleys on each side.

The pelvic bones are fixed in the new position for some weeks, and

[1] *Centralbl. f. Chir.*, vol. xlix, December, 1885; *Annals of Surgery*, vol. xlii, 1906, p. 281.

during this time some form of apparatus must be applied to remove the urine. Three or four months after the first operation closure of the bladder is attempted. The mucous membrane is dissected up at its junction with the skin, and the bladder-wall raised along this line and

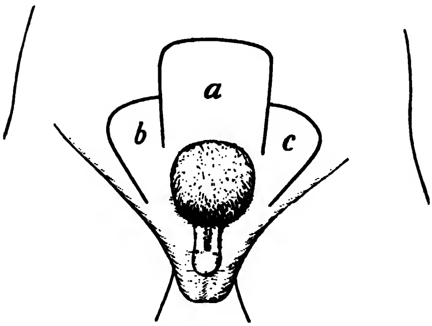


FIG. 241. WOOD'S OPERATION FOR ECTOPIA VESICÆ. *First stage. a*, Median flap; *b, c*, lateral flaps.

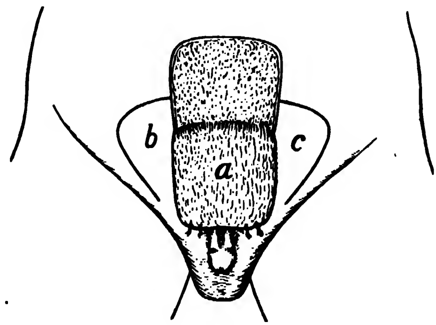


FIG. 242. WOOD'S OPERATION FOR ECTOPIA VESICÆ. *Second stage.* Median flap, *a*, turned down over the vesical defect.

the edges brought together. Over this the recti muscles and skin are sutured in the middle line. When the bladder has been successfully closed, an attempt may be made to reconstruct the urethra.

FIG. 243. WOOD'S OPERATION FOR ECTOPIA VESICÆ. *Third stage.* Lateral flaps, *b, c*, turned over the median flap, *a*.

Wood's operation. This operation consists in closure of the vesical defect by means of skin flaps, and should be performed about the age of four or five years. Several operations are usually required, and they should be completed before puberty, when hairs grow upon the skin flap and erections of the penis interfere with the operation.

If puberty be already passed, some means should be adopted to remove the pubic hairs.

Three flaps are used in the operation, one from the abdominal wall above the bladder, which is turned over with the skin surface inwards, and one flap from each side, which covers over the first flap.

The median superior flap has a narrow base at the upper margin of the defect, and a broad expansion at its upper part in the region of the

umbilicus (see Fig. 241). The length and breadth must be rather more than sufficient to cover in the gap which exposes the bladder defect. From the centre of each side of the superior flap an incision commences which outlines the lateral flaps. This is carried outwards and sweeps round an oval area at the side of the defect in the bladder. The base of each lateral flap is at its lower end and carries the superficial epigastric and external pudic arteries. The inner border of the flap passes along the margin of the exposed mucous membrane and on to the lateral surface of the penis. The flaps contain skin and as much tissue as is considered safe to remove without weakening the abdominal wall. The median flap is turned down and stitched over the gap, so that the skin surface forms the anterior wall of the bladder (see Fig. 242). The lateral flaps are raised and twisted inwards, so that they meet in the middle line and cover the exposed under surface of the median flap (see Fig. 243). The trefoil surface thus laid bare is either covered in at once by skin grafts or allowed to granulate and grafted later.

Implantation of the ureters in the rectum. Fowler[1] introduced a method of implantation of the ureters in the rectum in which he endeavoured to preserve them from contact with the fæces. He cut the ureters obliquely and formed a flap valve of mucous membrane from the anterior wall of the rectum. To the under surface of this he attached the cut end of the ureters, so that the descending fæces would press upon the valve and close the ureteric orifices. In closing the rectal wound the ureters were made to lie for a considerable distance between the mucous and the muscular coats of the bowel.

A boy of six years operated on in this manner was well two years later, and passed urine from the rectum every three hours. For the details of this and the succeeding method the reader is referred to the original articles.

Gersuny[2] made an artificial anus at the sigmoid flexure, and closed the upper end of the rectum. He then transplanted the ureters into the rectum.

Peters introduced catheters into the ureters and dissected them from the bladder, leaving a collar of the mucous membrane round the orifice of each. An incision was made in the perineum and the anterior wall of the rectum exposed. Two small openings were made through the rectal wall, and the catheters and ureters drawn through into the rectal cavity. Each ureter projected about 3 centimetres into the cavity. They were not fixed, and adhesions formed in three days, when the catheters were removed.

[1] *Amer. Journ. of the Medical Sciences*, 1898, vol. cxv, p. 270.
[2] *Wien. klin. Wochenschr.*, 1898, No. 43.

Soubottine's operation.[1] An incision is made from the anus to the base of the coccyx, and this bone is excised. The posterior wall of the rectum is then slit up longitudinally, cutting through the anal sphincter. An incision is made through the anterior wall of the rectum and the posterior wall of the bladder, and a fistula created in this situation by suturing the edges of the wound. A horseshoe incision with the convexity upwards is now made round the vesico-rectal fistula, and including about one-third of the circumference of the rectal wall. The limbs of the horseshoe pass down to the skin at the anus. The portion of the rectal wall included in this horseshoe incision is now formed into a reservoir resembling an inverted bottle by stitching the edges carefully together. Finally, the rectal wall is united over this, and the wound in the posterior wall of the rectum closed and the anal sphincter repaired. A receptacle is thus formed of rectal mucous membrane in which the urine may collect without contamination by the contents of the rectum. The neck of the receptacle is in the grasp of the anal sphincter, so that continence is assured.

At the time of the operation, or after an interval, the suprapubic gap in the bladder is closed by a skin-flap operation leaving an opening at the lower part of the bladder, which is closed later.

In one patient operated in this manner, Soubottine obtained complete continence, and the urine was retained for four hours.

Maydl's operation.[2] In this operation the trigone of the bladder, together with the ureteric openings, is transplanted into the sigmoid flexure of the colon.

A catheter is introduced into each ureter. The abdominal wall is incised at the junction of the mucous membrane of the bladder and the skin at the upper margin of the defect. Two fingers of the left hand are introduced into the peritoneal cavity to act as a guide. The incision is carried round the whole circumference of the bladder to the edge of the urethral gutter (see Fig. 244). If one of the ureters opens near the skin a portion of the skin must be removed with it.

Having separated the bladder from the abdominal wall the urethra is cut across immediately above the orifices of the ejaculatory ducts. The ureters are now very carefully separated in the lower part of their pelvic course, taking care not to interfere with the blood-vessels which supply them. The bladder-wall is then cut away, leaving an oval area on which the ureters open. The peritoneum is cut more widely than the mucous membrane, so that a border of peritoneum overlaps the muscular tissue. The abdominal wound is now extended upwards in the middle line, and the sigmoid flexure of the colon brought out. A knuckle of this is isolated

[1] Wratsch, 1901. [2] *Wien. med. Wochenschr.*, 1896, vol. xlvii.

with bowel clamps. This loop is incised longitudinally along its free border, and the wound held open with forceps. The flap of bladder-wall with the ureteral orifices is fitted into the opening in the intestine by twisting it round (see Fig. 245). The mucous membrane, muscle, and peritoneum are now united to those of the bowel by successive rows of catgut sutures.

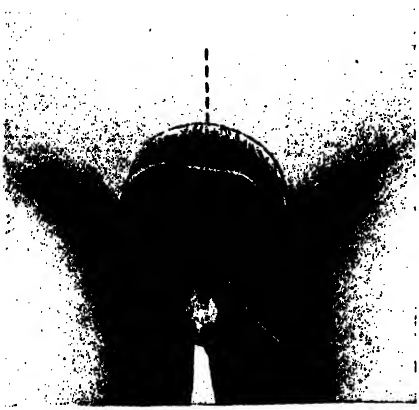


FIG. 244. MAYDL'S OPERATION FOR ECTOPIA VESICÆ. *First stage.* Isolation of the bladder. The oval portion of bladder-wall within the dotted line is preserved, the remaining portion is cut away.

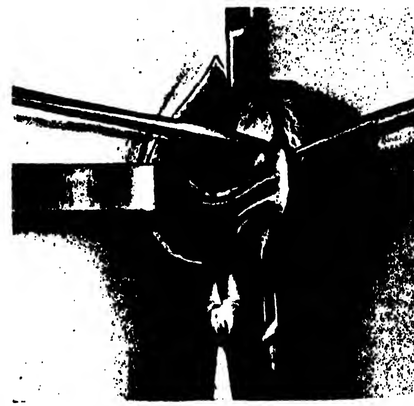


FIG. 245. MAYDL'S OPERATION FOR ECTOPIA VESICÆ. *Second stage.* Implantation of the bladder base with the ureteral orifices in the sigmoid flexure.

Sonnenberg's operation. Sonnenberg[1] implanted the ureters in the urethra after excision of the bladder in several cases of ectopia. An incision is made at the junction of the skin and mucous membrane, and the bladder dissected up without opening the peritoneum. The ureters are cut across and the bladder removed. The ureters are brought up to the surface and stitched to the edge of the urethral gutter. The abdominal wound is now closed. Where the ureteral orifices are not widely separated, and the mucous membrane is in good condition, Sonnenberg leaves the trigone and extirpates the remaining portion of the bladder.

Difficulties, dangers, and results of these operations. Trendelenburg's operation is designed to allow the edges of the deficient abdominal wall to come together so that a bladder might be formed of vesical mucous membrane alone.

The objection to these operations is that, even where they are successful, there is no sphincter to the new bladder. The patient is therefore incontinent, and an apparatus must be worn.

[1] *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1895; Ref. *Centralbl. f. Chir.*, 1895, p. 117.

In twenty-five cases collected by Katz, three were stated to have the power of retention of urine. The mortality of the operation was 22%.

Implantation of the ureters into the bowel may be immediately followed by general peritonitis from giving way of the line of union. To obviate this, Maydl recommends that the intestine should be fixed in the wound. Peterson [1] found an operative mortality of 32% in twenty-eight cases of uretero-intestinal implantation.

When the union is successful there is a serious danger of ascending pyelonephritis. The ingenious methods of Frank and Soubottine are designed to prevent this. The method which has proved most successful in avoiding the occurrence of ascending pyelonephritis is that of Maydl, where the trigone is transplanted with the ureters, so that the natural openings are preserved. If larger portions of the bladder be transplanted into the bowel, the risk of sloughing from want of blood-supply is increased.

Stenosis of the new opening when the ureters only are implanted, and kinking of the ducts in any of the operations, are further dangers.

The following statistics show the immediate mortality of Maydl's operation :—

Collector.	*Number of cases.*	*Number of deaths.*	*Mortality per cent.*
Peterson	36	5	13·8
Brandsford Lewis [2]	22	3	13·6
Katz [3]	57	15	26·7
Orloff [4]	56	11	19·8
Hartley [5]	46	7	15·0
Watson [6]	42	9	21·4
Mazel [7]	14	2	14·3
Josśerand [8]	18	1	5·5

In nineteen cases of uretero-intestinal anastomosis that recovered, Peterson found that nine succumbed later to some renal affection. One patient with a single ureter implanted in the bowel was alive and well eight years after the operation.

Of the thirty-one patients that survived Maydl's operation, two patients died of pyelitis four and fifteen months respectively after the operation. Of the other cases, the control of the anal sphincter was reported as very good in all except one case. Six fistulas following the operation were noted as having subsequently closed.

[1] *Medical News*, August 11, 1900.
[2] *Annals of Surgery*, June, 1900. [3] Quoted by Albarran, *loc. cit.*
[4] *Annales des maladies des organes génito-urinaires*, 1902, No. 11.
[5] *Medical News*, August 29, 1905. [6] *Annals of Surgery*, December, 1905.
[7] *Beitr. z. klin. Chir.*, p. 423. [8] *Gaz. hebdom. de Méd. et de Chir.*, 1898.

CHAPTER XII

OPERATIONS FOR THE REPAIR OF VESICO-VAGINAL FISTULÆ

To promote success in an operation for vesico-vaginal fistula the following points must receive attention:—

1. The urine must, if possible, be rendered aseptic. Urinary antiseptics should be freely administered.
2. Calculi must be searched for and removed from the bladder and cystitis reduced by washing with non-irritating antiseptic solutions.
3. Inflammation of the vagina and vulva must be treated with soothing douches and lotions.
4. Free drainage of the urine should be established for at least a week before the operation and provided for after the operation.
5. At the operation free access to the fistula must be obtained. The vagina is frequently scarred and narrowed in these cases, and a preliminary plastic operation may sometimes be required in order to give access to the fistula. Dilatation by large bougies has been recommended.
6. The ureters must be properly safeguarded by the passage of a catheter or bougie along each duct before beginning the operation.

There are three methods of approach when a vesico-vaginal fistula is to be repaired: (1) Vaginal; (2) Vesical; (3) Intraperitoneal.

Examples of the first method only will be described; the other methods have only been used in exceptional cases, and the reader is referred to the special works dealing with the subject for the details of the operations.

Closure by paring the edges and suture. For this operation the vaginal wall must be supple and the edges of the fistula easily approximated. Small fistulæ low down in the bladder and larger fistulæ high up in the vagina where the tissues are lax are most suitable.

The patient is placed in the dorsal position with the knees and thighs fully flexed and the pelvis raised on a sand-pillow or an Albarran's perineal elevator.

A large vaginal retractor is placed in the posterior wall of the vagina and smaller retractors on each side.

The edge of the fistula is grasped with toothed forceps and pared with a fine-bladed knife or curved sharp-pointed scissors with long handles. If there is a fibrous ring this must be completely removed; but before cutting away any considerable ring of tissue the surgeon should make certain that no tension will be caused when the edges of the wound come to be approximated. Oozing is stopped by pressure with a small swab or by irrigation with hot lotion. Stitches of silkworm-gut or strong catgut are now introduced through the whole thickness of the vaginal and vesical walls without penetrating the vesical mucosa (see Fig. 246). These should be inserted in the direction in which the edges of the wound will most easily come together. Finally a vaginal douche is given and a plug of aseptic gauze placed in the vagina.

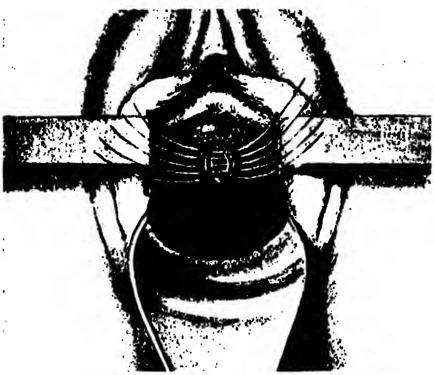


FIG. 246. OPERATION FOR VESICO-VAGINAL FISTULA BY PARING THE EDGES AND SUTURE.

FIG. 247. ALBARRAN'S OPERATION FOR VESICO-VAGINAL FISTULA. The dotted line traces the incision.

A Pezzer's self-retaining catheter is now placed in the urethra and retained for seven days. After that a catheter is passed at regular intervals for two or three days.

Albarran's operation. The following operation, described by Albarran,[1] is on the lines first practised by Mackenrodt [2]:—

An incision is made around the edge of the fistula and this is prolonged on each side (see Fig. 247). By dissection the vesical and vaginal walls are separated for about 1 to 3 centimetres. The two flaps thus formed are seized with forceps and their proper motility assured, if necessary extending the incisions to bring them into apposition. The edge of the vesical portion of the fistula is now pared. The opening in the bladder is closed

[1] *Loc. cit.*

[2] *Centralbl. f. Gyn.*, No. 8, 1894.

by a purse-string suture or by a row of Lembert's sutures. Over this the vaginal flaps are closed by a series of interrupted catgut sutures. The vagina is then washed, and in order to make certain that the wound is firmly closed the bladder is distended with weak antiseptic lotion. If necessary supplementary sutures are introduced. A self-retaining catheter is introduced into the bladder and the outer end prolonged into a urinal. Albarran prefers, when possible, to catheterize the patient every two hours and later increases the interval. This surgeon does not place a tampon in the vagina after the operation, but merely applies a dressing to the vulva. The bladder is washed three or four times

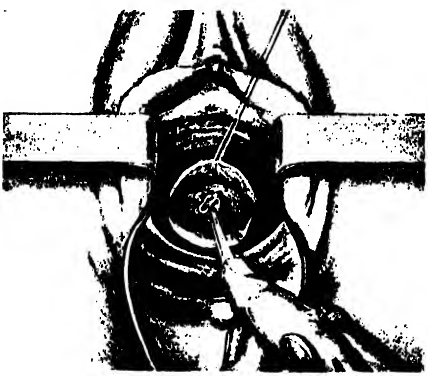


FIG. 248. BRAQUEHAYE'S OPERATION FOR VESICO-VAGINAL FISTULA. Invagination of the fistulous tube. (*Albarran.*)

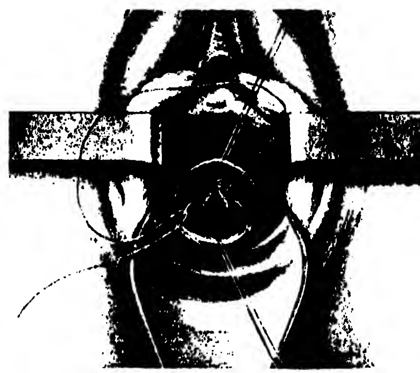


FIG. 249. ALBARRAN'S OPERATION FOR VESICO-VAGINAL FISTULA. Suture of bladder and vagina.

a day with a syringe filled with weak antiseptic solution (oxycyanide of mercury 1 in 4,000). In doing this the bladder should not be distended, only a small quantity of fluid being introduced at one time. The bowels are kept confined for four days.

The operation may be modified in the following points: An eliptical incision is made around the fistula and continued out on each side and a tube of mucous membrane dissected as far as the bladder mucosa. This tube is closed by Lembert's sutures and then invaginated (Braquehaye), or it may be invaginated and a row of Lembert's sutures introduced into the muscular tissues of the bladder and vagina over it (Albarran). The vaginal wall is then closed.

Author's operation. The following method has been practised by the writer where there is severe cystitis with a fistula rather larger than will admit a cedar-wood pencil, bound down by scar tissue at the upper part of the vagina. Adequate drainage of the bladder and some

means of traction upon the tissues around the fistula and free dissection of scar tissue are essential points.

Preparation. A week or ten days before the plastic operation the bladder is opened above the pubes. If calculi are present these are removed and the bladder is washed with a copious stream of antiseptic solution (biniodide of mercury 1 in 10,000 or oxycyanide of mercury 1 in 5,000). A large drainage tube, about $\frac{3}{4}$ inch in diameter and with one or two eyes near the vesical end, is introduced, and the bladder washing repeated daily, or twice a day if necessary.

During the week preceding the plastic operation, the vagina is washed daily with solutions similar to those used for the bladder, and a frequently changed tampon smeared with boracic ointment introduced into the vagina to prevent the constant soaking with urine. The operation is immediately preceded by a thorough cleansing of the vagina and bladder.

Operation. The patient is placed in the dorsal position with the thighs and knees fully flexed and the pelvis raised by means of a sand-pillow. A catheter is introduced into each ureter either through a speculum in the suprapubic wound or through the urethra by means of a Kelly's tube. A prostatic retractor—I prefer that of Young—is now introduced from the vagina through the fistula into the bladder. Traction is made by pulling upon this retractor, which is held in the left hand of the surgeon.

With a fine sharp-pointed long-handled knife an incision is made through the vaginal mucous membrane about $\frac{1}{8}$ inch from the margin, and this is deepened around the shank of the retractor (see Fig. 250). On each side of the fistula an incision is carried outwards transversely for an inch or more, and at the end of each incision a longitudinal incision is made $1\frac{1}{2}$ inches in length, the middle of which meets the end of the transverse one. The retractor is handed to an assistant and the edge of the flaps thus marked out is picked up in long-toothed forceps, and the flap dissected by means of a long-handled angled knife assisted by sharp-pointed curved scissors (see Fig. 251). The whole thickness of the vaginal wall is raised in each flap. The ureters are defined by touch and are carefully avoided. The incision round the fistula is deepened to the bladder mucous membrane and a small ring of tissue which formed the wall of the fistula is thus isolated around the shank of the retractor. With a fully curved Hagedorn's needle of small size held in a long holder a Lembert's suture of catgut is placed in the muscular wall of the bladder immediately in front of, and another behind, the fistula (see Fig. 252). The blades of the retractor are now closed and the instrument withdrawn, carrying with it the ring of tissue which formed the wall of the fistula.

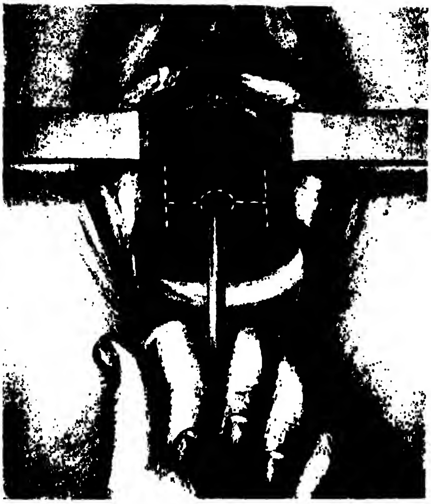


FIG. 250. AUTHOR'S OPERATION FOR VESICO-VAGINAL FISTULA. *First stage.* The dotted lines trace the incision in vaginal wall. The retractor has been introduced through the fistula and drags down and steadies the surrounding tissues.

FIG. 251. AUTHOR'S OPERATION FOR VESICO-VAGINAL FISTULA. *Second stage.* The fistulous track has been dissected up and the anterior flap raised. The posterior flap is being dissected up. The position of the ureters is shown at the anterior corners of the denuded area.

FIG. 252. AUTHOR'S OPERATION FOR VESICO-VAGINAL FISTULA. *Third stage.* The fistulous track has been dissected free around the shank of the retractor and the flaps raised. Lembert's sutures are being introduced in front of and behind the fistula.

Aided by traction upon the sutures a closely set row of interrupted catgut sutures is introduced from before backwards after the Lembert method in the muscle of the bladder-wall (see Fig. 253). The upper and lower vaginal flaps are now united by interrupted catgut sutures (see Fig. 254). The vagina is washed out and a soft roll of aseptic gauze

FIG. 253. AUTHOR'S OPERATION FOR VESICO-VAGINAL FISTULA. *Fourth stage.* Closure of the fistula by Lembert's sutures.

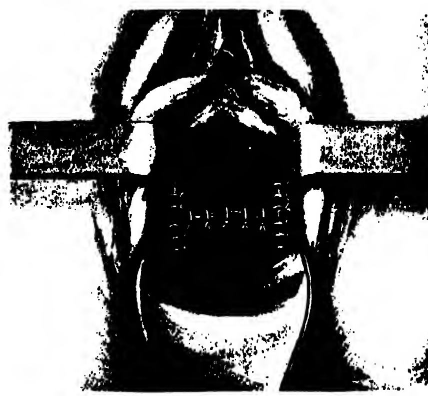


FIG. 254. AUTHOR'S OPERATION FOR VESICO-VAGINAL FISTULA. *Fifth stage.* The vaginal wound closed.

placed in the vagina so as to keep the vaginal and vesical walls in contact at the site of the operation. The vaginal retractors are removed and the legs extended. The bladder is washed through the suprapubic wound and the large rubber drainage tube reintroduced.

After-treatment. A White's suction apparatus is fitted (see p. 445) and the bladder kept dry. The bladder and vagina are flushed out daily in the same way as before the operation. The tube and suction apparatus are removed at the end of five days and the suprapubic wound allowed to heal.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART III

OPERATIONS FOR VESICAL CALCULUS

BY

P. J. FREYER, M.D., M.Ch. (R.U.I.)

Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

CHAPTER XIII

LITHOLAPAXY

CHOICE OF OPERATION

LITHOLAPAXY is the operation of choice in patients of all ages and both sexes. So far as mortality goes, there is little to choose between lateral lithotomy and litholapaxy in males below the age of puberty; but the period of convalescence after the latter may be reckoned in days, instead of weeks in the former. Even in the most experienced hands there will remain a certain proportion of cases in which litholapaxy will be inapplicable and in which a cutting operation must be had recourse to. These may be summarized thus :—

1. Huge calculi, *viz.* of about 2 ounces in weight and upwards, are best treated by suprapubic lithotomy, though soft phosphatic stones of much larger dimensions can be successfully dealt with by litholapaxy.

2. Suprapubic lithotomy is almost invariably indicated for encysted calculus.

3. A calculus partially impacted in the prostatic urethra and which cannot be displaced into the bladder, to be crushed there, is best treated by median lithotomy.

4. Where, though the stone is not very large, the bladder is rigid, contracted, and irritable, resenting the presence of the fluid that is necessary for the safe performance of litholapaxy, lateral or median lithotomy should be employed according to the estimated size of the stone.

5. When tumour of the bladder coexists with stone, suprapubic lithotomy is indicated, so that the tumour can also be removed at the same time.

6. When tight fibrous stricture of the urethra coexists, median lithotomy is indicated, the stricture being cut at the same time, unless the stone is so large as to necessitate suprapubic lithotomy.

7. When enlargement of the prostate coexists with stone, the prostate and stone should be removed by the suprapubic route.

In these remarks regarding the choice of operation I have assumed that the surgeon is one with considerable experience in this branch of surgery. A very pertinent and practical question, however, is this—Assuming the stone to be an uncomplicated one of moderate size, what

is the operation that is likely to give the most favourable results in the hands of the general surgeon who only occasionally encounters a case of vesical calculus ? Unhesitatingly I say a cutting operation of some kind. The fashion in this country has in later years turned in favour of the suprapubic route : in India lateral lithotomy still holds the field. I am not aware that any hospital statistics have in recent years been published in England to guide us in our choice between these two operations. But if any conclusions may be drawn from general inquiries that I have made, I have a strong suspicion that statistics collected from a large number of London and provincial hospitals would be in favour of lateral lithotomy.

INSTRUMENTS

The crushing of the stone is accomplished by means of *lithotrites*, similar to those employed for the old operation of lithotrity, except that, owing to the increased scope of the new operation in dealing with hard and large calculi, some of the lithotrites employed for adults are constructed much larger and stronger than those formerly in use. On the other hand, owing to the more recent extension of the modern operation to male children of the most tender ages, extremely small and slender lithotrites are now employed. In Fig. 255 is illustrated a lithotrite constructed on the well-known model of Weiss and Thompson. It possesses the cylindrical handle introduced by Sir Henry Thompson, which (in the words of the inventor) 'enables you, in the search for a small stone or fragments, to execute rapid and delicate movements which would be impossible in an instrument without the cylindrical handle'. It also possesses the new mode of changing sliding into screwing action, and *vice versa*, introduced by Weiss. When the small button in front of the cylinder is pushed back into the position indicated in the illustration, the instrument is 'locked', and then the male blade moves within the female blade by a screwing action only ; but when the button is pushed forwards in the direction of the blades, the instrument is 'unlocked', and the screwing is converted into a sliding action. The male blade, which is deeply serrated or toothed, passes through the female blade, driving the débris through the opening in the latter, or tossing it away on either side, so that no blocking of the blades by fragments can occur.

In Bigelow's lithotrite (see Fig. 256) the cylindrical handle of Thompson's instrument is retained for the left hand ; but instead of the wheel for the right hand a ball is substituted. This is an undoubted improvement, affording a much firmer grip, a point of great importance when dealing with a large and hard calculus. But the special feature of Bigelow's lithotrite is the introduction of a new mode of locking the instru-

ment. This is effected simply by a quarter rotation of the right wrist, whilst the hands are in position, without any displacement of the fingers; whilst a quarter rotation of the wrist in the opposite direction unlocks the instrument. In the lithotrites of Weiss and Thompson, the thumb of either hand has to be disengaged to move the button, a performance which tends to render the lithotrite in the bladder unsteady at the critical moment of catching the stone. By the ingenious device of Bigelow this objection is obviated—a decided improvement.

I cannot say, however, that I like the blades of this instrument nearly as well as those of the fenestrated lithotrites by Weiss and Thompson already described. 'The blades of this lithotrite consist of a shoe, or female blade, the sides of which are so low that a fragment falls upon it; while the male blade, or stamp, offers a series of alternate triangular notches, by whose inclined planes the detritus escapes laterally after being crushed against the floor and rim of the shoe. At the heel of the shoe, where most of the stone is usually comminuted and where the impact is therefore greatest, the floor is high and discharges itself laterally, while its customary slot is made to work effectually' (Bigelow). The blades are essentially non-fenestrated, and liable to get clogged with débris, as I have frequently found in practice, and therefore objectionable.

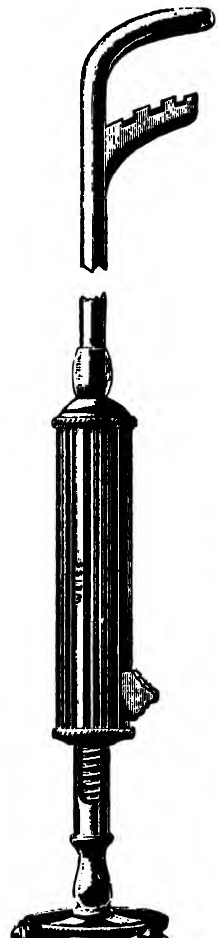


FIG. 255.
LITHOTRITE (*Weiss and Thompson pattern*).

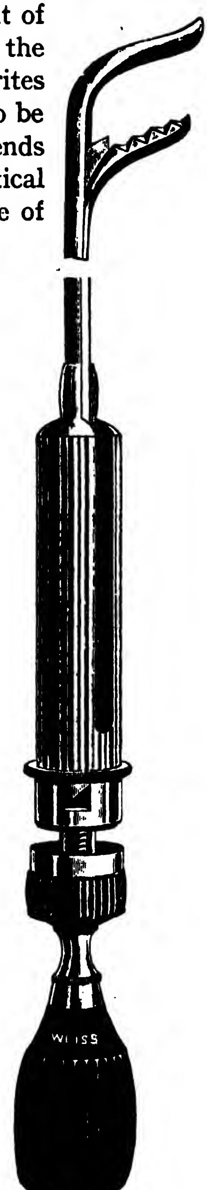


FIG. 256.
BIGELOW'S LITHOTRITE.

In 1886 I had constructed for me by Weiss a lithotrite (see Fig. 257), in which the handle and locking action of Bigelow are combined with the fenestrated blades of Weiss and Thompson. The female blade is completely fenestrated, the male blade passing right

through, so that when closed their under surfaces are flush with each other, and thus all fear of impaction of fragments is avoided. The upper edges of the female blade are smooth, and bevelled on their inner aspect, so that there is much less chance, in unpractised hands, of the mucous

FIG. 257.
FREYER'S LITHOTRITE.

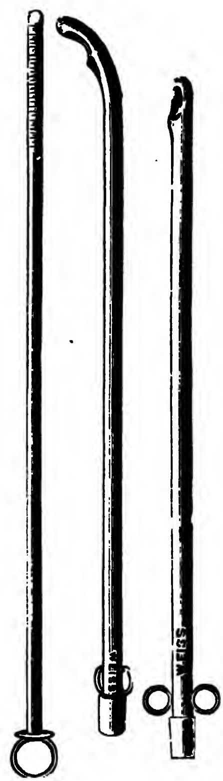


FIG. 258.
CANULÆ AND STYLET.

FIG. 259.
BIGELOW'S ORIGINAL ASPIRATOR.

membrane of the bladder getting nipped between the blades than in those lithotrites in which the upper edges of the female blade are toothed. Over twenty years' acquaintance with this lithotrite enables me to say that it is practically perfect in its working, and it is the model on which my lithotrites have since been constructed.

The second object aimed at in the operation, the removal of the débris from the bladder, is accomplished by means of large cylindrical tubes, or

evacuating catheters, introduced through the urethra, and an aspirator, or suction apparatus, attached thereto.

The canulæ employed vary in size according to the capacity of the urethra, Nos. 6 to 11, English scale, being used for male children, and Nos. 12 to 18 for adults and females of all ages. In my own practice I have not found it necessary to use a larger canula than No. 18, and through a tube of this calibre I have removed the débris of a calculus weighing 6¾ ounces. I have, however, met with cases in which a No. 19 or 20 canula might have been passed with facility. Canulæ (see Fig. 258) are made of thin silver, and vary in shape, some being straight, and some slightly curved at the extremity. The latter I prefer as I find them more easy to introduce. The orifice, or eye, should be large enough to admit any fragment that will pass through the tube. The canulæ should be armed with stylets (see Fig. 258) for reasons that will appear later on.

FIG. 260. BIGELOW'S IMPROVED ASPIRATOR.

FIG. 261. FREYER'S ASPIRATOR.

The original *aspirator* of Bigelow is represented in Fig. 259. It consisted of an elastic bulb or central portion, to the lower extremity of which was attached a removable cylindrical glass receiver; whilst from its upper part passed an india-rubber tube, the end of which fitted on to the evacuating catheter previously introduced into the bladder. By alternate expansion and compression of the bulb, the water was pumped into, and withdrawn from, the bladder, and the débris which was carried back into the aspirator fell down into the glass receiver, and was there retained.

This aspirator was gradually modified and improved by Bigelow himself and others. The modification of Bigelow's aspirator represented in Fig. 260, with which I worked for several years, I found very efficient. In 1895 I had this latter aspirator simplified still further (see Fig. 261) by dispensing with the tap above the rubber bulb, which was not really necessary, as the apparatus can be easily filled through the front tap, to which the canula fits. This may be effected still more rapidly by removing the glass receiver from the bulb, immersing both in a basin full of fluid, and then attaching the glass receiver to the bulb whilst the whole apparatus is immersed in the fluid. In this way all air is excluded. I have employed this aspirator exclusively for many years. It is very light and handy and thoroughly efficient in all respects.

IN ADULT MALES

Operation. It will be well to submit the patient to preliminary treatment for a few days previous to undertaking the operation. The patient should be put to bed and placed on a light nourishing diet. The bowels should be regulated, a purgative being given should constipation exist, and mild astringents should the patient suffer from diarrhœa, which is often the case.

For the operation I find a low, narrow operating table the most convenient. The patient is placed on this, close to the right edge, with his head resting on a pillow. The buttocks are raised by means of a low cushion placed beneath them. This is an important point, as the stone thus gravitates to the base of the bladder, away from the neck, and renders the latter part, which is the most sensitive, less likely to be injured in the various manipulations. The legs and thighs are flexed and slightly abducted.

It is very essential that the patient should be protected by warm clothing during the operation to prevent chill. For this purpose a pair of large woollen stockings should be slipped on, reaching up the thighs close to the groins.

Close to the operator's right hand should be placed a small table, with a tray or basin containing warm carbolic lotion, in which the lithotrites and evacuating catheters should be placed ready for use; while the aspirator, previously filled with warm boric lotion, should be entrusted to an assistant conversant with its working. It is well, when possible, to have two or three aspirators ready at hand, to be used alternately. The operation is thus facilitated, as while the surgeon is using one, a second can be emptied of débris and refilled with water by the assistant.

Before undertaking the operation of litholapaxy the surgeon must

learn to pass all instruments—lithotrites, sounds, and catheters—on the right side. This requires only a little practice to do it with ease, and much time is saved thereby. Besides the loss of time involved, it is extremely awkward to see a surgeon passing the instruments on the patient's left side, and then going round to the right side to use them.

The patient now being, as a rule, anæsthetized, the surgeon, standing on his right side, should first pass a large conical steel sound into the bladder. A series of highly-polished sounds of this kind (see Fig. 262), from No. 6 to 18, should be at hand. They should be made slightly tapering to the point, so that the diameter there is two sizes smaller than higher up at the bend. Solid heavy sounds of this kind are easily passed, and are handy for ascertaining the capacity of the urethra, and for facilitating the passage of other instruments. It will frequently be found that, when neither a catheter nor a lithotrite will pass into the bladder, a heavy sound of this shape will do so; and on its withdrawal the lithotrite or canula may be slipped in. The meatus is, as a rule, the narrowest part of the urethra, and it will occasionally be found necessary, in order to pass the large instruments employed in litholapaxy, to enlarge it slightly. Should, therefore, a large sound not pass, this must be done at once. For this purpose a director is introduced into the urethra, and the floor of the meatus is incised by means of a long slender scalpel.

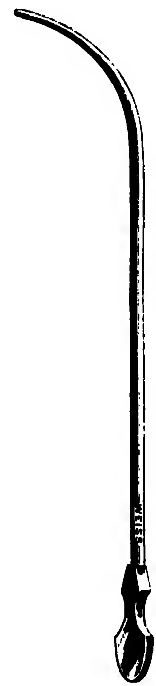


Fig. 262.
Graduated Steel Sound.

The question now arises as to the quantity of water the bladder should contain during the crushing of the stone. As a rule, a very small quantity, from 2 to 4 ounces, will be sufficient to protect the walls of the bladder, and at the same time permit of the necessary movements of the lithotrite. A large quantity of water is objectionable, involving an increased area over which the fragments, impelled by the currents set up by the movements of the lithotrite, may roam, thus increasing the difficulty in catching them. If, on the other hand, the bladder be completely empty, injury to its walls may result from the lithotrite.

The lithotrite is now introduced thus: The operator stands obliquely, with his left side towards the patient's face. The lithotrite, previously screwed home, locked and lubricated, is held horizontally in the right hand by the cylindrical handle, with the beak pointing downwards. The penis is grasped between the thumb and the two first fingers of the left

hand, and the beak of the instrument is introduced into the urethra (see Fig. 263), the penis being drawn slowly but steadily on to the lithotrite, which is gradually elevated till it reaches the perpendicular position (see Fig. 264), as it slides along the canal, which it does by its own weight. The beak will now have entered the membranous portion of the urethra as it passes through the triangular ligament. By gently depressing the handle of the lithotrite in the middle line towards the horizontal position, the beak will be found to slip along the membranous and prostatic portions of the urethra and into the bladder.

The lithotrite being thus introduced, the next stage of the proceedings consists in *catching the stone*. For this purpose the lithotrite is passed

FIG. 263. INTRODUCTION OF THE LITHOTRITE. *First position.*

FIG. 264. INTRODUCTION OF THE LITHOTRITE. *Second position.*

gently onwards, or, rather, allowed to proceed by its own weight, along the trigone, till it reaches the most dependent part of the base of the bladder, on which it is allowed to rest. The instrument is then unlocked, and the blades opened by withdrawing the male blade an inch or more, according to the size of the stone, the female blade being held steadily in position by the left hand on the cylindrical handle. The blades are now closed, when, frequently, the stone will be found between them (see Fig. 265). The lithotrite is locked, and lifted slightly off the base of the bladder, and the stone is crushed by screwing the male blade home (see Fig. 266). The instrument is again unlocked, the blades opened and closed, when a fragment will be caught and crushed as before. This process is to be repeated several times, till a considerable quantity of fine débris is made. Sir Henry Thompson compares the finding of frag-

ments to fishing for perch—where one is found there will many be caught. We must not go searching about the bladder for fragments till those in the locality in which the stone is first found are disposed of. The depression in the base of the bladder, caused by the weight of the lithotrite resting on it, facilitates the stone, and subsequently its fragments, falling on to the female blade.

Should the stone not be found by the manœuvre above indicated, it must be searched for. This is done by opening the blades of the lithotrite, turning them at an angle of 45° towards the right, and again towards the left, and closing them in these positions respectively. Should the stone still evade detection, the handle of the lithotrite must be depressed

FIG. 265. LITHOLAPAXY. *Searching for the calculus.*

FIG. 266. LITHOLAPAXY. *Crushing the calculus.*

towards the horizontal position between the thighs, pushed an inch or so towards the posterior surface, and the same manœuvres gone through in that position, searching centrally, right, and left. The stone will probably be found in one of these positions; but sometimes it lies immediately behind the prostate, especially when that gland is enlarged. To grasp the stone in this position the handle of the lithotrite should be depressed between the thighs, and turned right round on its axis, so that the beak points towards the trigone, but should not touch it. The blades are then opened and closed as before in this position, and if the stone lies there it will be secured. In fact, the surgeon should make a mental survey of the whole bladder, and institute a methodical search of every part of it till the calculus is found. All the movements must be light and graceful, and care taken that the mucous membrane is neither caught between the blades nor otherwise injured. In whatever position found,

the stone must be brought to the centre of the bladder and there disposed of.

Let us now assume that the stone, or a portion of it if a large one, has been reduced to fine débris. Should the stone be a small one—say, from a few grains up to 3 or 4 drachms in weight—its complete pulverization will probably be accomplished before the lithotrite is withdrawn, in a period varying from one to eight or ten minutes. But should the stone be a large one, a considerable amount of crushing, lasting over ten minutes or so, must be effected before removing the instrument. Before withdrawing the lithotrite, it must be locked and the blades screwed tightly home, so as to render them free of débris. I may here say that no instrument should be withdrawn from the bladder till quite free of fragments.

FIG. 267. LITHOLAPAXY. *Aspiration of débris.*

The evacuating catheter, armed with a stylet, should now be passed into the bladder, the largest size that the capacity of the urethra will easily admit being used. As soon as the stylet is withdrawn, a rush of water and débris will take place, to receive which a porringer should be at hand. The experience already gained in passing the solid sounds and lithotrites will afford a rough estimate of the size of the canula that the urethra will admit.

The canula having been introduced into the bladder, the aspirator, previously filled with warm boric lotion, is applied, the tap turned on, and the aspiration of the débris begun. The right hand grasps the bulb of the aspirator, by the compression and expansion of which water is injected into, and withdrawn from, the bladder (see Fig. 267). With the outward stream the fragments are carried, and are seen to fall into the glass receiver, where they remain. Should the stone be a small one, and have been completely crushed at the first introduction of the lithotrite, it will be found that, after the aspiration has gone on for a time, the whole of the débris will have passed into the receiver. But if the stone be a large one, after a considerable quantity of débris has entered the receiver, which will vary with the amount of crushing at the first introduction of the lithotrite, little or no débris returns with the outward stream, but a

rattling sound takes place, due to the fragments too large to pass out being carried with force against the eye of the canula.

The aspirator is then removed, the canula, rearmed with the stylet, is withdrawn, and the lithotrite again introduced for the purpose of crushing more fragments. This is followed by the canula and aspirator as before. This process may have to be repeated many times, according to the size of the stone, before the whole of the débris is removed.

In the healthy urethra of an adult there are only two situations, as a rule, where difficulty may be encountered in the passage of instruments, *viz.* at the triangular ligament, and at the neck of the bladder. The instrument (lithotrite or canula) should first be passed as far as it will go in the direction of the anus, thus depressing the floor of the urethra in front of the triangular ligament. 'Traction on the penis next effaces this depression, and adds firmness to the urethral walls; so that, if the instrument be withdrawn a little, and at the same time guided by the bony arch above, it can be coaxed without difficulty through the ligament in question—a natural obstruction which physicians often mistake for a stricture. The obstruction passed, the rest of the canal is short, and corresponds with the axis of the body' (Bigelow).

The obstruction sometimes met with at the neck of the bladder is due to the firm lower edge of the inner meatus. This may be overcome by pushing the lithotrite or canula gently onwards in the direction of the axis of the body, imparting to it a slightly rotatory motion if necessary.

When the urethra is capacious, and large evacuating catheters can be passed, as in the great majority of cases in the adult, it is unnecessary to reduce the stone to fine sand, as coarse débris can pass through these tubes into the aspirator, and it is waste of time to reduce the débris to a finer consistence than what will pass through the canula with facility.

During the earlier part of the process of aspiration, the end of the canula should be kept towards the centre of the bladder, raised from the base, and may be moved about slightly in various directions to facilitate the flow of the fragments towards the eye; but towards the completion of the process the canula should be allowed to rest on the base, so as to gather up the sand and last fragments.

Towards the completion of the operation it will be found that, as a rule, the last particles of débris lie close to the neck of the bladder, just behind the prostate. This is due to the fact that the eye of the canula being turned towards the posterior aspect and sides of the bladder, the water is less disturbed by currents in the position referred to than in any other. Consequently, the last particles of débris gravitate towards this spot. Towards the end of the operation, therefore, the eye of the canula should always be turned right round towards the prostate, and water

forcibly injected, so as to dislodge the débris from this position. This manœuvre is especially necessary where enlargement of the prostate co-exists, otherwise a fragment might be left behind.

On compressing the bulb and pumping water into the bladder, the débris is scattered away from the eye of the canula. Before allowing the stream to return by the expansion of the bulb the hand should rest a second or two, so as to allow the débris to settle down again in the vicinity of the eye. The evacuation of the débris will sometimes be found to take place best by injecting 2 or 3 ounces of water into the bladder with each compression of the bulb; at others a much smaller quantity will be found more effectual. No definite rule can be laid down for all cases.

It sometimes happens, even when the patient is fully anæsthetized, that spasm of the bladder occurs. During its existence all manipulation should be suspended, otherwise the bladder might be injured. Should the lithotrite be in the bladder, it must be closed and kept unmoved till the spasm passes over. If the canula be in the bladder, the water should be allowed to escape.

During the process of aspiration, with each expansion of the india-rubber bulb the fragments of calculi are carried against the eye of the canula by the outward rush of water, and a clicking sound is thus produced, which, whilst it continues, indicates that some fragments remain in the bladder. There is, however, a peculiar sound sometimes produced, the occurrence of which the young litholapaxist should be acquainted with, as it is very likely to be confounded with the sound produced by a fragment. This 'false sound', as it may be called, is produced by the mucous membrane of the bladder being sucked into the eye of the canula during the exhaustion of the water. It is most likely to occur towards the end of the operation, when all, or nearly all the fragments have been exhausted, and especially when the bladder contains no surplus water, only that quantity which is pumped in and withdrawn during compression and expansion respectively of the bulb. It may, however, be produced at any time if, after compressing the bulb, the eye of the canula be turned towards the sides, or directed up against the apex of the bladder, and the bulb of the aspirator be then allowed to expand. The sound itself, though difficult to describe, can never be mistaken when once recognized. The sensation communicated to the hand is of a fluttering, jerky character, accompanied by a dull, muffled sound as contrasted with the clear ringing click which the impact of fragments imparts to the instrument. On its occurrence the outward stream receives a sudden and complete check; whereas when a fragment obstructs the stream, a portion of the water continues to flow. The sound does not recur if the canula be partially

withdrawn and raised towards the perpendicular position so as to bring the eye close to the neck of the bladder, with the end of the canula resting on the trigone ; whereas a fragment will produce obstruction there as well as in any other position. On first practising litholapaxy I was deceived by this sound, and since then I have seen many inexperienced litholapaxists similarly deceived.

It frequently happens that, during the process of aspiration, a fragment which is too large to pass through the canula gets caught in its eye. This is recognized by the fact that the outward stream is arrested, and the bulb of the aspirator ceases to expand. The fragment should at once be displaced. This, as a rule, may be effected by compressing the bulb suddenly and with force, when the fragment will, as a rule, be expelled by the inward stream. Should this manœuvre fail after being tried two or three times, a stylet should be introduced through the canula, and the fragment displaced in this way. But the canula should on no account be withdrawn with the fragment sticking in its eye, as in this way the urethra may be injured, or the fragment get caught in the mucous membrane, displaced from the eye of the canula, and thus impacted in the urethra.

Should a fragment get impacted in the urethra, how are we to deal with it ? If the precautions indicated in the last paragraph are taken, there will be little fear of its occurrence. Still, it is an accident that has to be reckoned on. If the fragment be lodged in the prostatic portion of the urethra, it may easily be displaced backwards into the bladder by passing a large canula as far as the obstruction, applying the aspirator, and injecting water with some force, when, as a rule, the fragment will rush back into the bladder, to be there disposed of. If the fragment be arrested in the anterior 3 or 4 inches of the canal, it can be removed with one or other of the various kinds of urethral forceps in use (see Fig. 268). When deeply placed in the membranous portion of the canal, it may still be removed in this manner; but, if tightly impacted, it may be necessary to remove it by external urethrotomy, an occurrence which, however, I have never seen.

Where there is great irregularity of the inner surface of the bladder, it may be extremely difficult to get rid of the last fragment. I have experienced this frequently. The aspirator is applied, and time after time the fragment clicks against the eye of the canula, but, on introduction of the lithotrite, the fragment cannot be grasped. Great perseverance may be necessary, especially if the fragment be a broad thin shell from the outer crust of a large stone. A manœuvre that I have found useful is to employ the suction force of the canula and aspirator to bring the fragment out of the depression in which it lies, close to the neck of the

bladder, and then to introduce the lithotrite and catch the fragment in this position. If the fragment lies in a depression behind the prostate, the forefinger may be introduced into the rectum. The lithotrite being in the bladder, the fragment of stone may now be pushed out of the depression in which it lies by the point of the finger, and caught by the lithotrite with a little manipulation.

As a rule, there ought to be little or no loss of blood attending the operation, with the exception of the trifling bleeding that follows the incision in the floor of the urethra, when this is necessary to enlarge the meatus. I have frequently removed very large calculi with scarcely a tinge of blood in the washings from beginning to end. In some cases, however, the mucous membrane of the prostatic urethra is highly sensitive to the passage of instruments, and considerable bleeding takes place. In such cases I am in the habit of using a weak astringent in the washings—say $\frac{1}{4}$ grain of acetate of lead to the ounce—and winding up the proceedings with a stronger solution.

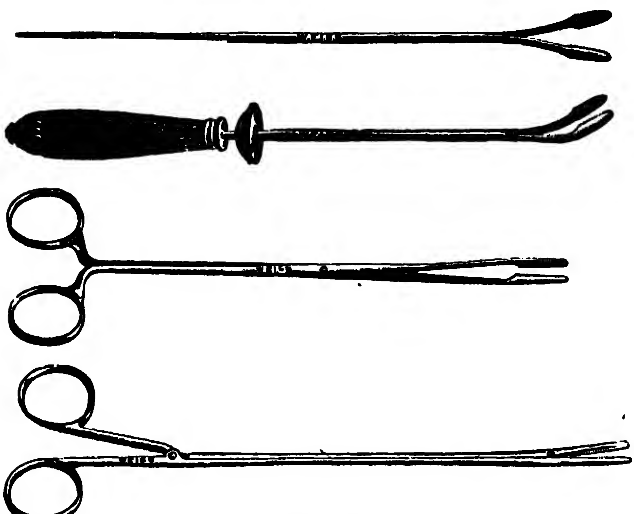


FIG. 268. URETHRAL FORCEPS.

After-treatment. The operation being completed, the patient should be put to bed, and well wrapped up in warm clothing. A morphia suppository should be at once introduced. The food for the first few days should be of a light kind, consisting mainly of milk and soups. A demulcent and alkaline drink should be allowed.

For the first twenty or thirty hours the urine may be tinged with blood, particularly till the operator has had large experience in this branch of surgery, and there will, as a rule, be considerable burning sensation along the course of the urethra, with some difficulty of micturition. Should there be any pain or tenderness on pressure in the region of the bladder, hot fomentations assiduously applied to the hypogastric region will also be found soothing; and pain in the perineal region will be lessened by fomenting these parts.

Complications. Retention of urine is a rare sequel of the operation, for which a hot hip-bath will be found most effectual. Should this fail, recourse must be had to the catheter. More rare still is total suppression of urine, which should be dealt with on general medical principles. This occurs only in patients whose kidneys are diseased, and is of very grave import.

When the patient is the subject of enlargement of the prostate, it may be advisable to pass and tie in a soft catheter for a few days, to allow the water to flow in this way.

Acute inflammation of the testicle is a sequel of the operation that has from time to time occurred in my practice, and readily yielded to the ordinary treatment for that complication.

The most frequent sequel of the operation is the occurrence of the ordinary catheter or urethral fever, long recognized as attending the passage of instruments through the urethra, and the supervention of this fever is a contingency that will have to be reckoned with in a considerable proportion of the cases dealt with. The attack sets in, as a rule, a few hours after the operation, frequently after the first act of micturition, and passes through the usual stages—cold, hot, and sweating—of an ordinary attack of intermittent fever, from which it is scarcely to be distinguished. The treatment will also be the same as in ague—extra warm clothing, hot-water bottles to the extremities, and the administration of hot drinks, particularly tea, during the cold stage. As this passes into the hot stage, part of the clothing must be removed, and the patient's thirst relieved by copious drinks of water, lemonade, &c. The ordinary diaphoretic mixture should also be given to encourage perspiration. When the sweating stage sets in, warm clothing must be again supplied to encourage perspiration, and prevent the patient catching cold. During the intermission quinine should be given. The fever is, as a rule, very amenable to treatment.

The beginner will do well to commence by operating on cases where the stone is small and the urethra capacious. As experience is acquired, large calculi and those attended by complications are to be attacked.

Previous to undertaking the operation for the first time it will be well, when possible, for the surgeon to pay a visit to one of those hospitals where the operation is performed. More information will be gained by seeing the operation once well performed, than by any amount of reading and theoretical knowledge.

The length of time occupied by the operation will vary, of course, with the size and consistence of the stone, the capacity of the urethra, the facility with which the instruments can be introduced, and the experience and dexterity of the operator. I am now in the habit of crushing as much

of the stone as possible before withdrawing the lithotrite, so that in most cases of stone of ordinary size only one introduction of the instrument is necessary. The repeated introduction of instruments should, I think, be avoided as much as possible. Rapidity of execution is a quality which comes with practice; and there is no doubt that, all undue haste and roughness of manipulation being avoided, it is desirable to complete the operation as rapidly as possible, particularly when the patient is old and much enfeebled by the disease.

The patient is, as a rule, anæsthetized during the operation. During the last few years, I have, however, been performing the operation without an anæsthetic in an increasingly large number of suitable cases. With a capacious urethra in an adult I should not hesitate to attack a stone of about an ounce in weight without the aid of an anæsthetic, or with local anæsthesia by cocaine only, in a case in which the internal administration of an anæsthetic was undesirable, or strongly objected to by a patient.

Difficulties. There are certain complications met with in connexion with the operation of litholapaxy to which I will now direct attention.

Large calculi. With a capacious urethra in an adult male, there being no enlargement of the prostate, and the bladder being roomy and non-sacculated, the experienced litholapaxist should have no difficulty in disposing of a stone of moderate dimensions—say, under 2 ounces in weight. When, however, a stone, if at all hard, exceeds this weight, the operation becomes a much more serious and difficult one. I find that among my series of 1,035 litholapaxy cases there were 37 weighing 2 ounces and upward; 9, 3 ounces or over; and 1, $6\frac{1}{8}$ ounces.

The removal of large calculi of these sizes demands much patience, skilful manipulation, and manual labour. It is, indeed, no light or easy task, and will be found to call forth all the resources of the surgeon. Before attacking a stone of 2 ounces and upwards by litholapaxy a surgeon should have considerable experience in dealing with smaller calculi.

After introducing the lithotrite there may be considerable difficulty in grasping the stone between the jaws of the instrument, owing to the walls of the bladder contracting on it, particularly as calculi of these sizes are frequently attended by chronic cystitis, resulting in contracted bladder with thickened walls. To overcome this difficulty, as much warm boric lotion as the bladder will retain should be injected before introducing the lithotrite, so as to separate the walls of the viscus from the stone, and thus allow room for manipulating the jaws of the instrument on to it.

It will sometimes be found, in dealing with large calculi, that though the lithotrite will not lock should the stone be first grasped by the long axis,

it will do so if this is changed for the short axis of the stone. This manœuvre should always be tried before abandoning the case as unsuitable for litholapaxy. And here I may mention that experience has taught me that, as a rule, a stone lies in the bladder with its long axis in the antero-posterior direction.

When we have to deal with a phosphatic stone of such a size that the largest lithotrite that the urethra will admit cannot lock on it, the jaws of the instrument should be dug into its sides and then screwed home, this process being repeated over and over again. In this way we can, by scraping its surface, and chipping off portions, if the calculus be irregular in shape, frequently reduce it to such dimensions that the lithotrite can lock on it, when it is easily disposed of.

Urethral stricture. Of all the complications met with in the treatment of stone by litholapaxy, the most difficult to deal with is, perhaps, the presence of organic stricture of the urethra. To permit of the large instruments employed in this operation passing through the urethral canal, the stricture must first of all be disposed of. This will be accomplished by either internal urethrotomy or dilatation, according to the nature of the stricture. If the case be one suitable for dilatation—that is to say, if the stricture be soft, elastic, and dilatable—this is best done by passing rapidly in succession a series of conical steel sounds (see Fig. 262) two or three times larger at the bend than at the point, till the canal is sufficiently dilated; and then at once introducing the lithotrite and disposing of the stone. If the stricture be tight but dilatable, it will be well to commence its dilatation a couple of days before the operation by tying in gum-elastic catheters of successively larger sizes till No. 8 or 10 is reached, and then, on the day of the operation, completing the dilatation by large conical steel sounds rapidly passed in succession. If, however, the stricture be hard, fibrous, and non-dilatable, it must be dealt with by internal urethrotomy immediately before the operation for the stone.

Hypertrophied prostate. Enlargement of the prostate is a complication which, contrary to what might be expected, as a rule offers little obstruction to the performance of litholapaxy. In passing the instruments over the enlarged prostate a little extra manipulation may be necessary. When obstruction is met with in the prostatic portion of the urethra, I find the manipulation of depressing the handle of the lithotrite between the thighs, and pushing it onwards with a slightly rotatory or boring motion in the direction of the axis of the body, frequently successful in entering the bladder. Should this fail, it will be necessary for the surgeon to change from the right side of the patient to the left, and, by means of the forefinger of the left hand in the rectum, holding the lithotrite in the

right, to endeavour to guide the point of the instrument over the obstruction into the bladder.

When considerable hypertrophy of the prostate exists, and particularly when there is a median outgrowth, owing to its projection into the bladder, there is naturally a pouch formed between the posterior surface of this organ and the base and posterior wall of the bladder. It is in this pouch that, as a rule, the stone lies; and, in order to catch it there, it will frequently be necessary to turn the jaws of the lithotrite round so as to point downwards, and then to open them in this position, when, by a little manipulation, the stone, and subsequently its fragments, will be caught.

When the patient is dependent on the catheter, care must be taken to draw the urine off three or four times daily after the operation; or a soft rubber catheter may be tied in and the urine allowed to flow by this for a few days.

There is generally a good deal of bleeding during the performance of litholapaxy when the prostate is enlarged. It is necessary in such cases to exercise great care in removing the last fragments, for they frequently get embedded in clots of blood in the bladder, which have to be broken up by frequent washings by the aspirator, and then removed with the entangled débris of stone.

We must not expect, however, to be successful in performing litholapaxy in every case in which hypertrophy of the prostate occurs in connexion with stone in the bladder. It will occasionally be found that, even when a large steel sound can be passed readily into the bladder in such cases, no amount of manipulation will enable us to pass a lithotrite, with its sharply curved beak. The use of force of any kind in passing instruments in such cases must be carefully avoided; and if the lithotrite cannot be coaxed in by that amount of manipulative skill which the surgeon from his experience has acquired, the idea of performing litholapaxy must be abandoned, and suprapubic or perineal lithotomy had recourse to, according to the circumstances of the case.

With the brilliant success now attending the operation of enucleation of the enlarged prostate, it is rare indeed that the surgeon will stop short at litholapaxy in such cases, the operation of choice being the removal of the stone suprapubically, followed at once by enucleation of the prostate. Still, cases will occasionally occur in which conditions of general health may contra-indicate the more radical operation, but in which removal of the stone by litholapaxy may be advisable, to ameliorate the painful symptoms due to this cause.

Partially impacted calculus. A difficulty is sometimes met with, both in passing instruments and catching the stone, when the calculus lies stationary, growing partly in the bladder and partly in the prostatic

portion of the urethra. From one's experience of lithotomy, the difficulty of managing such cases may be easily imagined. Every lithotomist of any experience must have come across cases in which an irregular, elongated calculus lies with its main portion or body, in the bladder, and a small elongated head in the prostatic urethra, the two portions being united by a neck corresponding with the vesical orifice of the urethra (see Fig. 269). Such a calculus must, if possible, be displaced from its position backwards into the bladder before being crushed; otherwise lithotomy will have to be performed.

FIG. 269. CALCULUS PARTLY VESICAL AND PARTLY URETHRAL. The neck of the bladder gripped the constricted portion.

The manœuvre by which this is accomplished is as follows: The largest canula that the urethra will admit is passed as far as the stone lying in the prostatic portion of the canal. The aspirator is then applied, and water pumped with force into the bladder. The force of the stream dilates the prostatic urethra, which thus loosens its grip on the stone and the latter is displaced backwards into the bladder, where it is disposed of by the lithotrite.

IN MALE CHILDREN

For the performance of litholapaxy in male children it is essential that the surgeon should be provided with a series of small fully fenestrated lithotrites of the same patterns as those used for adults, but varying in size from No. 4½ to 10. It will be found that in boys aged from thirteen to sixteen years a lithotrite of size No. 11 or 12 will pass readily as a rule. The canulæ employed are also similar in shape to those used for the adult, but vary in size from No. 6 to 11, English scale. The smaller sizes should not be more than 7 inches in length, as the return stream through these small canulæ is very weak, and diminishes in strength with the length of the tube. The aspirator is the same as for adults; but it must, of course, be worked very gently, only a small quantity of water, proportional to the size of the bladder, being thrown in. Any smaller or weaker apparatus will not suffice to extract débris through the narrow canulæ, owing to the stream being so feeble.

It will be found that the capacity of the urethra in patients of the same age varies much more in children than in adults. Thus, the urethra of a child of five or six years of age will frequently be found to admit a No. 10 lithotrite with ease; in other instances a No. 6 is passed with difficulty.

The meatus of the urethra in children is, as a rule, very narrow, and frequently requires to be enlarged to permit the litholapaxy instruments to pass. The incision should be on the floor of the urethra.

I find that in children, after the meatus has been enlarged, the first 2 inches of the urethra is, as a rule, the narrowest and most difficult part through which to pass the lithotrite; whereas in adults the difficulty, when one occurs, lies generally at the triangular ligament or prostatic portion of the canal.

In children the operation is, for the same size of stone, a much more tedious one than in the adult, owing to the small size of the instruments employed, and the necessity to grind the calculus into very fine débris before it will pass through the canulæ.

There is more danger of a fragment of stone being left behind in children than in adults. The stream passing through the small tubes employed has not the same evacuating force as in the larger canulæ used in adults. The débris is not, therefore, carried with the same certainty towards the eye of the canula from the various parts of the bladder; and the fragments do not give out the diagnostic clicking sound so clearly. It is therefore necessary to institute a very careful search by pumping in water and exhausting it, with the eye of the canula turned in various directions, before the instruments are finally withdrawn. In the hands of a careful and experienced surgeon there is little chance of a fragment being left behind.

Litholapaxy should not be attempted in a child when the smallest lithotrite at hand is a tight fit for the urethra. When the instruments fit tightly at first, there may be some difficulty in their reintroduction, or even in their withdrawal, owing to the congestion and swelling of the urethral mucous membrane that takes place near the meatus. I have noticed this phenomenon, but to a much slighter extent, in young adults, but never in old men.

When the urethra in a male child is capacious, and the calculus of moderate size, litholapaxy can be performed with facility; but when the urethra is very narrow, or the stone large, the operation is a difficult one. In any case, litholapaxy in male children is a much more delicate one than in the adult. I do not think that a surgeon would be at all justified in attempting this operation in a male child till he had had very considerable experience of it in the adult.

If it was necessary to caution the surgeon against the use of force in passing instruments in the adult, this is doubly necessary in the case of children, in whom the mucous membrane and other tissues are so delicate and easily lacerated.

IN FEMALES

Litholapaxy in females is, as a rule, not a difficult proceeding, the instruments employed being the same as for males. Even quite young female children admit large lithotrites and canulæ without any preliminary dilatation of the urethra. The only special difficulty met with is that, owing to the width and shortness of the urethral canal, the water which is necessary in the bladder during the crushing of the stone is liable to rush out beside the instruments. This difficulty is obviated by getting an assistant to place the fore and middle fingers of one hand in the vagina, and to press the posterior lip of the urethra against the lithotrite or canula, a manœuvre which prevents the water from flowing out. Litholapaxy in females is eminently successful, and the patient may be seen, as a rule, walking about the day after the operation. No forcible dilatation of the urethra being necessary, there is no incontinence of urine, that extremely troublesome sequel which sometimes follows the operation by dilatation.

CHAPTER XIV

LITHOTOMY

THE patient is prepared by having his bowels thoroughly cleared out by a purgative, in addition to which an enema is given a couple of hours before the operation. The perineum is shaved and purified, and an antiseptic dressing applied thereto.

LATERAL LITHOTOMY

Operation. The patient is placed on an operating table of convenient height and anæsthetized. A gum-elastic or rubber catheter is then introduced, the urine drawn off, and the bladder washed out with warm boric lotion till this flows clear. Six or seven ounces of the lotion are left in the bladder on withdrawal of the catheter. A staff of this shape

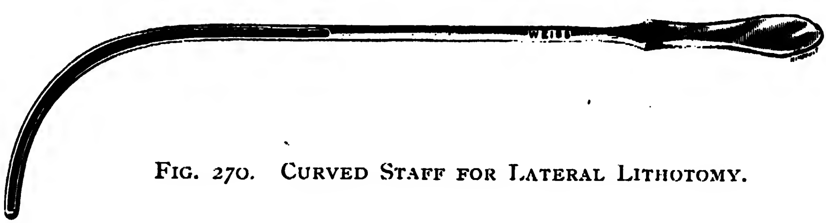


FIG. 270. CURVED STAFF FOR LATERAL LITHOTOMY.

(see Fig. 270), with a deep groove extending along the left side of the curved portion to within an inch of its point, and of the largest size that the urethra will readily admit, is then passed into the bladder, when the stone should be felt. Should the staff fail to reveal the presence of the stone, it must be withdrawn and a sound introduced to ascertain the position of the stone. On reintroduction of the staff the stone will be located. But on no account should the operation be proceeded with till the stone is definitely felt by the staff, lest the latter may have failed to reach the bladder, owing to its possible diversion into a false passage in the urethra.

The patient is now placed in what is called the 'lithotomy position' (see Fig. 271), that is, on his back with his thighs flexed on the abdomen and the legs flexed on the thighs, and with the buttocks projecting somewhat beyond the end of the table. He is held in this position by an assistant on either side. It was formerly the practice to bind the patient's

hands and ankles together on either side, and in recent years a Clover's crutch has been employed for keeping the lower limbs in position. All these appliances savour of pre-anæsthetic days, when it was necessary to secure the patient from struggling during the operation. They one and all interfere with the introduction and securing of the staff in position, and hamper the patient's breathing. There is no fixation arrangement equal to the aid of a couple of skilful assistants for this purpose, who can extend or flex the patient's limbs as required, and keep the parts symmetrically placed during the operation.

The staff is placed with the shaft perpendicularly and the concave aspect of the curved portion pressed against the roof of the urethra, beneath the pelvic arch, and then relegated to an assistant standing on one side, who with the second hand raises the scrotum up out of the field of operation.

FIG. 271. THE SUPERFICIAL INCISION IN LATERAL LITHOTOMY. (*Fergusson.*)

The surgeon passes a finger into the rectum to ascertain that it is empty and acquire a knowledge of the size and general conformation of the prostate. Having purified his finger, he sits on a stool of convenient height facing the patient's perineum, and passes the fingers along the bony arch of the pelvis so as to take in a mental grasp of the relative positions of the various structures.

The point of the knife (see Fig. 272)—one with a stout blade 3 inches long, and with a straight back—is then entered 1½ inches in front of the anus and slightly to the left of the central raphe, and an incision 2½ to 3½ inches long, according to the stoutness of the patient, boldly made outwards and downwards to about an inch beyond the anus, in such a direction that it intersects an imaginary line drawn from the ischial tuberosity to the anus at the junction of its middle and outer thirds (see Fig. 271). By this incision, which should be deeper towards the centre than at the ends, the skin and subcutaneous tissues are freely divided; but no attempt should be made to reach the staff in the first instance. The knife is applied once or oftener to the exposed fat and cellular tissue, and the forefinger of the left hand is then introduced deeply into the wound between the accelerator urinæ and the erector penis muscles, when the

groove in the staff will be felt at the membranous portion of the urethra. The finger-nail is fixed in the groove as far back as possible to protect the bulb. The blade of the knife is then passed along the back of the finger with its edge directed outwards and downwards, and the membranous urethra incised, so that the point of the knife is felt grating against the

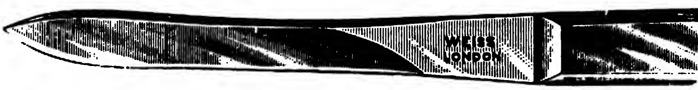


FIG. 272. SHARP-POINTED LITHOTOMY KNIFE.

groove of the staff (see Fig. 273). Keeping the point of the knife carefully in the groove, it is pushed along till it reaches the bladder, cutting through the side of the urethra and notching the left lobe of the prostate. On withdrawal of the knife the incision is enlarged downwards and outwards to an extent proportionate with the estimated size of the stone.

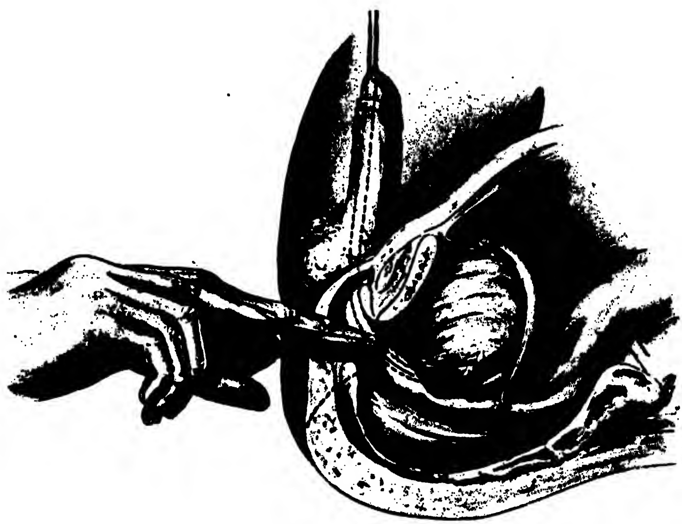


FIG. 273. THE DEEP INCISION IN LATERAL LITHOTOMY. (*Fergusson.*)

The forefinger of the left hand is then passed along the staff into the bladder, dilating the wound in its progress. When the surgeon is assured that the finger has reached the bladder, either by his feeling the stone, or by the sensation of its lying in a large smooth-walled cavity, the staff is withdrawn. The neck of the bladder and the deep wound are then further dilated by twisting the finger about, and the stone located, if it has not already been felt lying, as it usually is, close up against the inner orifice of the urethra.

Forceps of the type seen in Fig. 274—of which several pairs of various sizes, some straight and others curved with spoon-shaped blades roughened on the concavity, should be at hand—are then passed along the finger, and as the point enters the bladder the finger is slowly withdrawn, and the blades are at the same moment opened, when a gush of lotion will take place, and frequently the stone be carried into the jaws of the instrument. Should the stone not be thus caught at once the instrument is moved about in search of the stone, the blades being gently opened and shut, over and over again, perhaps, till the stone is secured. Before attempting to withdraw the stone the forceps are moved about in the bladder to ascertain that they are free, lest a fold of the mucous membrane should be engaged in their grip.

The forceps, with the contained stone, is then gently withdrawn by a side-to-side alternating with a rotatory movement, downwards and backwards first and then forwards and upwards, in the axis of the pelvic outlet, avoiding pressure on the upper aspect of the urethra beneath the pelvic arch. If there be much obstruction to its advance the finger should be introduced beside the forceps to ascertain that the stone is grasped by its long axis, if it be an elongated one. If the stone be large a certain amount of force will be required for its extraction, but enlargement of the wound by the knife is preferable to bruising of the tissues at the neck of the bladder by the employment of much force.

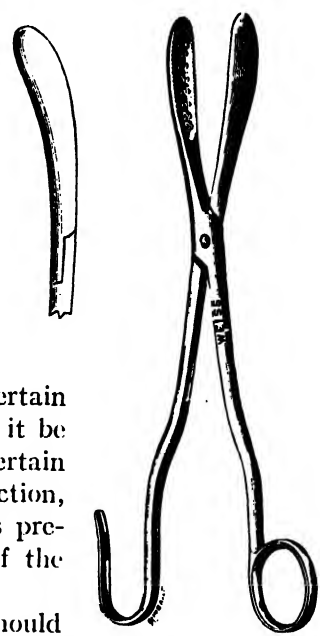


Fig. 274. Lithotomy Forceps.

On the removal of the stone the finger should be reintroduced and the bladder thoroughly explored to ascertain if a second or more calculi be present. Pressure on the hypogastrium with the other hand will bring the distal portions of the bladder within reach of the finger.

If the stone be broken during extraction, as is frequently the case when it is phosphatic, or if several small calculi be present, a scoop (see Fig. 275) will be found more convenient than forceps, the débris or calculi being held between the scoop and the tip of the forefinger in extraction.

There may be considerable hæmorrhage from the superficial perineal arteries, the deep branches of the pudic, particularly that which courses inwards to the bulb, or from the prostate. Superficial vessels are ligatured, and the deep ones also when practicable; should there be any difficulty

about this, catch-forceps may be applied and left in position for a day or two. Prostatic bleeding is best arrested by introducing a large stiff rubber drainage tube, and packing the wound around this with iodoform gauze if necessary. I have seen very profuse hæmorrhage into the bladder in my early lithotomy days in old men with enlarged prostates. Such cases are now, of course, treated by suprapubic removal of the stone and prostate.

The operation as just described is that which I practised in my early lithotomy days in India. Later on I abandoned the curved staff in favour of a practically straight one (see Fig. 276), resembling Key's, save that the end is somewhat more curved for facility of introduction. The groove is median and extends just as far as the bend.

Further, after making the superficial incision in the perineum I assume charge of the staff, holding it in my left hand whilst I pass the knife along its groove into the bladder. The sympathy between the two hands enables one to judge of the position of the groove, and at once strike it off with the point of the knife.

Some surgeons are in the habit of laying aside the sharp-pointed knife when the groove in the staff has been reached and completing the incision by means of a probe-pointed knife (see Fig. 277) slid along the groove, by this means obviating the possibility of injuring the bladder with the point of the scalpel. For the novice this is a wise precaution, but unnecessary for the practised lithotomist, particularly if the bladder contains a considerable quantity of fluid, as it always should do before commencing the operation.

If the patient be very stout or the prostate enlarged, the finger may fail to reach the bladder. A gorget with blunt edges (see Fig. 278) is in such cases passed into the bladder along the groove of the staff, which is then withdrawn, and the forceps introduced along the concavity of the gorget.

An imperative precaution during this operation is, *always to have some guide in the bladder (whether staff, finger, gorget, or forceps) and never to withdraw one till another is fairly in that viscus.* Otherwise you may fail to reach the bladder, an unfortunate accident likely to be attended by disastrous results.

The rectum is liable to be wounded during this operation. This accident is obviated by taking care that the lower bowel is thoroughly emptied before the operation, by keeping the staff well up against the pubic arch, and by directing the edge of the knife outwards, away from the anus in the direction already indicated. Should this accident occur, the wound is simply allowed to granulate without any active interference.

The operation being completed, a stout perineal drainage tube of stiff rubber (see Fig. 279) is inserted in the bladder, and retained in position

by means of a suture of silkworm-gut passed through it and the margins of the wound. The edges of the wound, if extensive, may be partially brought together by means of a suture or two. The bladder is then washed out through the tube with warm boric lotion to remove any clots of blood or grit that may be lying there. The tube is removed in the course of three or four days, when the urine passes by the wound for some days. The surface of the wound will have begun to granulate and be covered by plastic lymph, thus preventing absorption from septic urine. Urine will begin to pass by the urethra at periods varying from one to three weeks. In aged patients, the subjects of prostatic enlargement, the period was much longer; but cases of this kind would now, as already explained, be dealt with suprapubically.

Fig. 275. Lithotomy Scoop.

Fig. 276. Straight Lithotomy Staff.

Fig. 277. Probe-pointed Lithotomy Knife.

Fig. 278. Blunt-edged Gorget.

Fig. 279. Perineal Drainage Tube.

The bed in which the patient is placed is, of course, protected by waterproof sheeting, and absorbent cotton-wool and cellulose thickly packed beneath the buttocks and along the perineum, being kept in position by a broad bandage. The dressings should be changed every

three or four hours, when saturated with urine. The usual precautions should be taken to prevent the skin in proximity to the wound getting irritated by the urine.

The operation in male children. In male children the largest staff that can be introduced with facility should be employed. Owing to the undeveloped condition of the parts and the delicate nature of the tissues there may be some difficulty in introducing the finger into the bladder, and if force be used the prostate and bladder may be pushed off the urethra up into the pelvis. To obviate such an occurrence a small blunt gorget should be passed along the staff into the bladder, and by this the wound is dilated. On withdrawal of the staff the finger can be introduced, or the forceps, which should be very slender, can be slipped along the gorget into the bladder.

In children a tube is unnecessary and irksome. The urine is allowed to flow by the wound from the first. Granulation takes place rapidly in them, so that the wound is frequently completely closed in a week or ten days.

MEDIAN LITHOTOMY

For this operation a curved staff with central groove is generally employed. An incision is made through the skin and subcutaneous tissues in the central line of the perineum, commencing 2 inches in front of the anus and extending downwards almost to its edge, merely cutting through the skin at the lower part of the wound. The forefinger of the left hand is then passed deeply into the wound and the groove of the staff is felt in the membranous portion of the urethra. The point of a long, slender, straight bistoury, with its edge downwards, is passed along the finger till it enters the groove of the staff and is then slid along it, cutting through the membranous urethra and nicking the apex of the prostate. No extensive wound of the prostate is necessary or desirable, as the prostatic portion of the urethra is roomy, and dilatable by the finger to such dimensions as will permit the withdrawal of any stone that can be removed by this method.

A blunt-edged gorget (see Fig. 278) is passed into the bladder along the groove in the staff, which is then withdrawn. The finger is now passed into the bladder along the gorget, which is in turn withdrawn. Then the forceps are passed along the finger, and the stone caught and removed as already described in connexion with the operation of lateral lithotomy.

Personally I always use the straight staff (see Fig. 276), which I hold in my left hand, and at once enter the knife straight into its groove, without any preliminary incision of the skin, cutting through the superficial parts as the knife is withdrawn.

A rubber perineal tube is tied in the bladder for two or three days, after which the urine is allowed to flow by the wound till it closes. The after-treatment is the same as for lateral lithotomy.

Only calculi of comparatively small sizes can be removed by this method, and such are best dealt with by litholapaxy. This operation should be reserved mainly for those cases in which the stone is impacted in the prostatic urethra, or growing partly there and partly in the bladder (see Fig. 269), and which cannot be dislodged backwards into the bladder for removal by litholapaxy.

There is scarcely any bleeding unless the bulb is encroached on during the incisions.

The operation is frequently performed by inserting the knife with its back downwards in front of the anus, and cutting in an upward direction on the staff, the forefinger of the left hand being placed in the rectum. I consider the other method superior.

SUPRAPUBIC LITHOTOMY

Operation. The operation of suprapubic cystotomy, by which the stone is reached and extracted, will be found described in detail on p. 430. The bladder having been opened, the stone is located by the left index-finger. Lithotomy forceps (see Fig. 274) are then introduced; the stone is caught between the blades, and gently withdrawn through the wound.

The extent of the wound in the bladder will depend on the size of the stone. Should it be necessary to enlarge the wound first made by the knife, this is best done by introducing the two index-fingers and gently tearing the bladder-wall by separating them to the required extent. In this way hæmorrhage is reduced to a minimum. It is better to enlarge the wound than to use undue force in extraction of the stone, by which the bladder-wall would be bruised, thus probably leading to sloughing of the tissues.

When the stone is small, or if several be present, the scoop (see Fig. 275), aided by the point of the index-finger in the bladder, will be found more efficient than forceps. Should the calculus be phosphatic it will probably break up during extraction, in which case all the débris must be carefully removed by the scoop, and by flushing out the bladder with warm lotion.

On completion of the operation a stout drainage tube is introduced into the bladder and fixed in position by a suture. Around this the edges of the abdominal wound are loosely brought together; and, speaking generally, the after-treatment is similar to that already described in connexion with suprapubic cystotomy (see p. 434).

RESULTS OF OPERATIONS FOR VESICAL STONE

The late Sir Henry Thompson collected details of 1,827 lateral lithotomies performed in British hospitals previous to the introduction of the operation of litholapaxy, showing 229 deaths, or a mortality of 12·53 %. Amongst these there were 799 adults, with 161 deaths, or 20·15 %, and 1,028 children, with 68 deaths, or 6·61 %.

In a paper published in the *Lancet*, March, 1885, I gave statistics of 2,592 lateral lithotomies performed in Indian hospitals in 1882, when litholapaxy was scarcely practised in that country, showing a mortality of 13 % on the whole—practically the same as in British hospitals.

Sir Henry Thompson had 1,007 operations for vesical calculus in his own practice, amongst which there were 136 perineal lithotomies, with 44 deaths, or 32·35 %, *viz.* 115 in adult males, with 42 deaths, or 36·52 %; 12 in male children, with 1 death, or 8·33 %; and 9 in females, with 1 death, or 11·11 %.

There were 19 suprapubic lithotomies, with 5 deaths, or 26·31 %.

There were 850 lithotrities, with 49 deaths, or 5·76 %, *viz.* 844 in adult males, with 49 deaths, or 5·80 %, 3 male children and 3 females being successfully operated upon.

Rapid dilatation of the urethra was the method of removal employed by him in 2 females, both successfully.

Sir Henry explains the high mortality from lithotomy in his practice by the fact that the worst cases were treated by cutting operations, lithotrity being employed in the less serious ones.

Furthermore he draws attention to the fact that of the crushing operations 472 were done by the old method of lithotrity by repeated 'sittings', with 37 deaths, or 7·83 %, whereas 372 were done by lithotrity at one sitting (Bigelow's operation), with 12 deaths, or 3·22 %.

In my own practice I have performed 1,443 operations for stone in the bladder. Amongst these there were 255 perineal lithotomies with 11 deaths, *viz.* 55 adult males, with 10 deaths, or 18·20 %, and 200 male children, with 1 death, or 0·50 %.

There were 149 suprapubic lithotomies, all in adult males, with 19 deaths, or 12·75 %. In 110 of these enucleation of the enlarged prostate was performed at the same time, with 14 deaths, or 12·75 %, and though, as previously stated, all these deaths are accepted in connexion with the latter operation, they are here again set down to the suprapubic lithotomy for statistical purposes. It is a remarkable fact that in my practice suprapubic lithotomy with enucleation of the prostate at the same time is not accompanied by a higher mortality than simple suprapubic lithotomy alone.

There were 1,035 litholapaxies, with 27 deaths, or 2·61 %, *viz.* 815 in adult males, with 25 deaths, or 3·06 %; 192 in male children, with 2 deaths, or 1·04 %; and 28 in females, all successful.

Vaginal lithotomy was performed in 1 female and removal of the stone by dilatation of the urethra in 3, all with success.

Of my 1,443 operations for stone, 864 were done in India and 579 in England. The mortality in both countries is practically the same.

From 1864 to 1908 inclusive there were 1,560 operations for stone in the bladder performed at St. Peter's Hospital, and the introduction of litholapaxy has been followed by a gradual decline in the death-rate from 15·25 % in the first decade to 3·87 % in 1904–8. In 1908 the mortality was only 1·61 %.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART IV

OPERATIONS UPON THE PROSTATE

BY

P. J. FREYER, M.D., M.Ch. (R.U.I.)

Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

CHAPTER XV

SUPRAPUBIC PROSTATECTOMY

Belfield of America must be credited with the first rational attempt, in 1886, at a radical operation for the removal of the obstruction caused by the enlarged prostate to the natural flow of the urine; but the operation became best known in this country in connexion with the name of McGill of Leeds, who, in 1888, brought it prominently to the notice of the profession. The operation consisted in opening the bladder suprapubically and removing the prominent portion of the prostate in the viscus. It was, however, merely a partial prostatectomy, and after enjoying a temporary popularity fell out of practice, owing to the high mortality attendant thereon, and to the fact that in a large proportion of the cases there was no improvement on the previous condition.

INDICATIONS FOR PROSTATECTOMY

When there is decided enlargement of the prostate in a person of advanced age giving rise to urgent symptoms necessitating the employment of a catheter as a daily routine for emptying the bladder of its residual urine, the operation of prostatectomy should be entertained and advocated, provided the growth be of such a nature that it is capable of being enucleated entire and that there be nothing in the age of the patient or in his general state of health to contra-indicate an operation of this magnitude.

In the great majority of cases referred to the consulting surgeon, the catheter will have been employed for weeks, months, or years, and in a large proportion of them the reference will be made owing to the supervention of one or more of the usual complications incident to so-called 'catheter life', *viz.* recurring cystitis, hæmorrhage, formation of vesical calculus, difficulty in introducing a catheter, &c., and in which there is practically no alternative but an operation. But prostatectomy is now attended by such a low mortality and such excellent subsequent results that the habitual use of the catheter should be anticipated, or at least the operation should be undertaken as early as possible after the use of the catheter becomes necessary, before the complications above referred to set in. When undertaken whilst the patient's general health is sound, and

before the advent of local complications, there is practically no danger in the operation in experienced hands, When these complications set in, as they invariably do sooner or later, and particularly when the kidneys become affected through the backward pressure of the urine, or through ascending pyelitis, the operation must necessarily be attended by considerable risk.

There is another consideration that should strongly weigh in favour of early operation, *viz.* that recent experience has demonstrated beyond doubt that the adenomatously enlarged prostate has a tendency in a large proportion of cases to assume a cancerous type under the irritating influence of the catheter and complications incidental to its habitual use.

To ascertain whether the prostate is capable of being enucleated entire in its capsule, the patient, if capable of passing any urine naturally, is directed to empty his bladder as far as possible, and is then placed on a couch in the recumbent position. The bladder is emptied of its residual urine by means of a catheter. The forefinger of one hand, previously lubricated, is slowly introduced into the rectum, and when the sphincter ani is thoroughly relaxed a survey of the rectal aspect of the prostate is made. If the organ be found to be decidedly enlarged, presenting a well-marked tumour in the rectum more or less rounded in shape, bilobed laterally, with a well-marked furrow in the median line, smooth on the surface, soft or somewhat dense to the touch, and (most important of all) movable, we know that we have to deal with the ordinary adenomatous enlargement of the gland of advanced life. If, in addition, from its prominence in the rectum we estimate the tumour to be at least of the size of a tangerine orange, the case may be regarded as in all probability one in which the prostate is capable of being enucleated entire.

We next proceed to make a bimanual examination of the prostate. This is accomplished by placing the fingers of the other hand on the hypogastrium and pressing them well down behind the pubic arch, at the same time directing the patient to relax the abdominal muscles. Counter-pressure is made by the finger in the rectum. If the prostate be decidedly enlarged it will be felt between the fingers of the two hands and can be slightly moved upwards, downwards, or from side to side, like a chronically enlarged uterus, but to a less extent. If it be very prominent in the bladder the outgrowth in that viscus will be easily recognized, and in thin subjects the origin of the outgrowth, whether from the right or left lobe, or from both. In thin or moderately stout patients this method of examination is easily accomplished and is most helpful for diagnostic purposes. In very stout patients it is less satisfactory. Occasionally we meet with patients who are unable to relax their abdominal muscles;

in such cases the examination can only be satisfactorily accomplished under the influence of an anæsthetic.

If on bimanual examination the prostate, with the characteristics already described, be felt distinctly, we can at once pronounce the case to be one in which the organ can be enucleated entire in its capsule, no matter what magnitude it may have attained.

It is, however, when we have to deal with adenomatous enlargements of the prostate of smaller dimensions—say, less than 1½ ounces in weight—that the greatest difficulties present themselves as to the possibility of their enucleation entire being practicable. For as the records of my published cases show, we may find complete dependence on the catheter, strange as it may appear, with a prostate weighing 1½ ounces, 1 ounce, or even less. A prostate of 1 ounce in weight will scarcely feel enlarged *per rectum*, or even bimanually, unless the patient be very thin. The only way we can determine with certainty the possibility of enucleating a prostate of this size is by the aid of the cystoscope. If on cystoscopic examination we find that there is a well-defined outgrowth of one lobe, or marked prominence of both lobes in the bladder, the case may be pronounced to be one permitting of enucleation of the gland entire, no matter what its size may be as felt *per rectum*.

TOTAL ENUCLEATION

In the *British Medical Journal* of July 20, 1901, I described my operation of total enucleation of the enlarged prostate and gave full details of four successful cases, the first of which had been undertaken on December 1, 1900.

Surgical anatomy. The prostate is in reality composed of twin organs, of apparently purely sexual function, which, in some of the lower animals, remain distinct and separate throughout life, as they exist in the human male during the first four months of fœtal existence. After that period, in the human fœtus, they approach each other, and their inner aspects become agglutinated together, except along the course of the urethra, which they envelop in their embrace.

These two glandular organs, which constitute the lateral lobes of the prostate, though welded together, as it were, to form one mass, remain, so far as their secreting substance and functions are concerned, practically as distinct as the testes, their respective gland-ducts opening into the urethra on either side of the verumontanum.

Each of these two glandular bodies, or prostates, is enveloped by a strong, fibro-muscular capsule; and it is these capsules—less those portions of them that dip inwards, covering the opposing aspects of the glandular bodies or lobes, and thus disappearing from view, being em-

bedded in the substance of the prostatic mass—that constitute the true capsule of the prostate regarded as a whole. This capsule extends over the entire organ except along the anterior and posterior commissures, or bridges of tissue that unite the lateral lobes in front of and behind the urethra, thus filling in the gaps between them. This true capsule is intimately connected with the prostatic mass, and is incapable of being removed from it even by dissection.

The urethra, accompanied by its surrounding structures—*viz.* its longitudinal and circular coats of muscles continued downwards from the bladder, its vessels and nerves—passes downwards and forwards between, and is embraced by, the inner aspects of the two glands or lobes.

The ejaculatory ducts enter the prostatic mass close together in an interlobular depression at the posterior part of its upper aspect, each duct coursing along the inner aspect of the corresponding lobe. They do not penetrate the capsules of the lobes, but pass forwards in the interlobular tissue to open into the urethra.

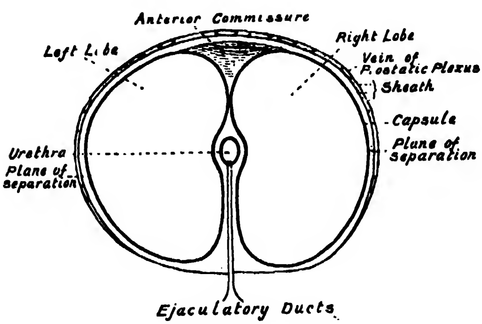


FIG. 280. THE STRUCTURE OF THE PROSTATE AND ITS ENVELOPING CAPSULES. (*Diagrammatic transverse section.*)

The prostate, thus constituted and enveloped by its true capsule, is further encased in a second capsule or *sheath*, formed mainly by the recto-vesical fascia, numerous connecting bands, however, passing between the two. The nomenclature here adopted is that suggested by the late Sir Henry Thompson in his work *The Diseases of the Prostate*, and is both scientific and practical. Embedded in the outer capsule or sheath, lies the prostatic plexus of veins, most marked in front and on the sides of the prostate. The diagram (see Fig. 280) shows the structure of the prostate and surrounding parts.

There is nothing I can call to mind that illustrates more simply and forcibly the composition of the prostate and its coverings than an orange. If we imagine the edible portion of an orange composed of two segments only, instead of several, with the septum between them placed vertically, we have a rough and homely illustration of the formation of the prostate. The strong fibrous tissue which covers the segments of the orange, and which is intimately connected with the pulp, represents the true capsule

of the prostate, the two segments or halves of the orange representing the two lobes. Further, the rind of the orange outside all represents the outer capsule or prostatic sheath formed by the recto-vesical fascia.

And here let me remark that in the operation that I shall presently set forth, it is this inner or true capsule as above described that is removed, the outer capsule or sheath being left behind, thus preventing infiltration of urine into the cellular tissue of the pelvis. The textbooks, as a rule, drew no distinction between the two separate coverings of the prostate, treating them both combined, or the outer one only, as the 'capsule'. To persons brought up in this school of thought and teaching my operation must at first sight necessarily have appeared impossible.

In most, if not all, cases of enlargement of the prostate of declining life (cancer being excluded) the overgrowth is adenomatous in character, numerous encapsuled adenomatous tumours being found embedded within the substance of the lobes, and frequently protruding on their surfaces. They sometimes assume the form of polypoid outgrowths which, however, are invariably enclosed within the true capsule, which is pushed before them.

My ideal operation at the outset consisted in enucleating the enlarged prostate entire in its capsule out of the encasing sheath, leaving the urethra with its accompanying structures behind. But, as will subsequently appear, I discovered at an early stage in the history of the operation that the prostatic urethra might be torn or even partially or entirely removed, with equally good eventual results.

Operation. The pubes having been previously shaved and the parts rendered aseptic, the bladder is thoroughly washed out with an antiseptic lotion, as in this disease the urine is almost invariably foul. The catheter employed for this purpose should be made of rather stiff gum-elastic, and be of the largest size that the urethra will readily admit.

Suprapubic cystotomy is now performed. After washing out the bladder the catheter is left *in situ*, and the viscus is distended with boric lotion. The nozzle of the large syringe employed for this purpose, which is filled with lotion, is inserted in the end of the catheter, thus acting as a plug to prevent leakage from the bladder, and the syringe being ready to further distend the bladder with fluid, if necessary, as the operation proceeds. An incision varying in length from 2½ to 3½ inches, according to the stoutness of the patient and the size of the prostate, is made in the median line of the abdomen, its lower end reaching to the level of the pubic arch. This incision is rapidly carried down through or between the recti muscles till the prevesical space is opened. Any bleeding vessels are clamped by catch-forceps, the forefinger is introduced into the lower angle of the wound, and the prevesical fat scraped upwards off the bladder by the

finger-nail for the whole length of the wound. The peritoneum, which should not be seen, is thus pushed upwards out of harm's way, and the bladder appears deeply in the wound, quite tense, glistening, and of a pale white colour, with large and tortuous veins coursing in its substance. Selecting an area devoid of veins, the point of the scalpel is plunged boldly into the bladder, and an incision about 1 inch long is made in the vertical direction towards the symphysis. The wound in the bladder can be subsequently enlarged if necessary; and this is best effected—as being attended by least bleeding—by separating two fingers placed in the wound, and thus tearing the bladder-wall to the required extent. On withdrawal of the scalpel the forefinger is introduced into the bladder as the lotion rushes out through the wound, and a general survey of the viscus is made. Should calculi be present they are at once removed by forceps or scoop.

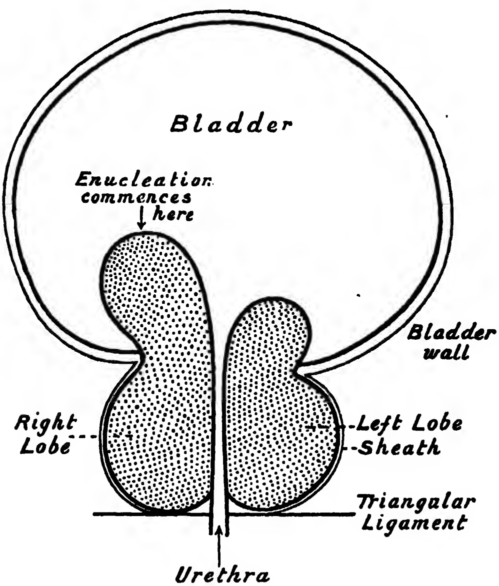


FIG. 281. HORIZONTAL SECTION OF THE PROSTATE AND THE BLADDER. Showing the point at which enucleation commences. (*Diagrammatic.*)

The forefinger of the other hand is next introduced into the rectum to render the prostate prominent in the bladder, and to keep it steady during the manipulation by the finger in the bladder. The mucous membrane over the most prominent portion of one lateral lobe (see Fig. 281), or over the so-called 'middle' lobe if there be but one prominence, is scored through by the finger-nail, and gradually detached by it from the prominent portion of the prostate in the bladder. This portion of the enlarged prostate is covered merely by mucous membrane, so that when this is scraped through and detached the true capsule of the prostate is at once reached.

Keeping the finger's point in close contact with the capsule, the enucleation of the prostate out of the enveloping sheath outside the bladder is proceeded with by insinuating the finger-tip in succession behind, outside, and in front of one lateral lobe, thus separating the capsule from the sheath. The finger is then swept in a circular fashion from without inwards, in front of, and to the inner side of the lobe, detaching this from

the urethra, which is felt covering the catheter, and pushed forwards towards the symphysis between the lateral lobes, which will, as a rule, have separated along their anterior commissure in the course of the manipulations. The other lobe is attacked and treated in the same manner. The finger is next pushed well downwards behind the prostate and the inferior surface of the gland is peeled off the triangular ligament. When the prostate is felt free within its sheath and separated from the urethra, with the finger in the rectum, aided by that in the bladder, it is pushed into the bladder through the opening in the mucous membrane, which, during the manipulations, will have become considerably enlarged.

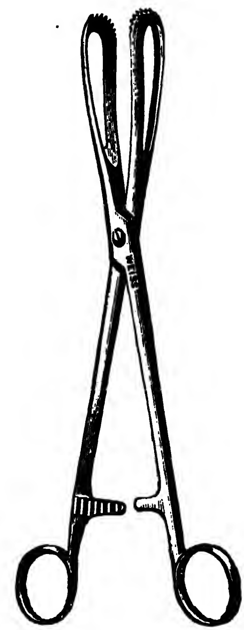


FIG. 282. FORCEPS FOR DELIVERING THE PROSTATE FROM THE BLADDER.

The prostate, which now lies free in the bladder, is withdrawn by strong forceps (see Fig. 282) through the suprapubic wound. And here I may remark that it is astonishing through what a comparatively small wound a very large prostate can be delivered, owing to the elasticity and compressibility of the adenomatous growth between the blades of the forceps. Sometimes the lobes become detached along both anterior and posterior commissures and come away separately.

The question now arises, What becomes of the ejaculatory ducts in the course of this operation? When the lobes come away separately they are probably left behind uninjured, attached to the urethra. When the prostate comes away as a whole, they may be torn across, or pulled out of the gland. But, as will subsequently appear, in the vast majority of my later operations, the distorted portion of the urethra behind the verumontanum has been removed with the prostate, the urethra being severed at the position at which the ejaculatory ducts enter it, the ducts as a rule remaining adherent to the portion of the prostatic urethra that is left behind.

Almost from the commencement I have abandoned the employment of any cutting instrument for incising the mucous membrane, finding the finger-nail alone most convenient and expeditious. Besides, when scalpel or scissors are employed there is danger of cutting the capsule, and the guiding line being thus lost, the finger flounders about inside, enucleating isolated adenomatous tumours instead of the whole organ in its capsule.

When I first conceived the possibility of removing the whole prostate, my ideal operation consisted, as already stated, in enucleating the enlarged

gland in its capsule out of the enveloping sheath, leaving the urethra behind; and this was the procedure undertaken in my earlier cases.

I have latterly almost completely abandoned the attempt to preserve the urethra entire in the enucleation of the prostate. The excellent permanent results obtained from partial removal of the urethra with the organ have convinced me that no advantage is to be gained by leaving the vesical end of the urethra behind. In a large proportion of cases of

FIG. 283. ENUCLEATED PROSTATE. Showing right, A, and left, B, lobes, and outgrowth, C, in the bladder growing from the left lobe. The catheter occupies the course of the urethra.

FIG. 284. ENUCLEATED PROSTATE. Showing right, A, and left, B, lobes, and enormous outgrowth, A′, B′, in the bladder derived from both lobes.

enlarged prostate this vesical end of the urethra is extremely dilated, being trumpet-shaped, or distorted out of any shape resembling a more or less circular tube as in the normal prostatic urethra (see Fig. 283). Even when it is left behind, I have always had my doubts as to its ultimate fate in most instances. The probability is that, through want of support and adequate blood-supply, it sloughed in large part, and came away in the washings during the after-treatment.

Examination of specimens of prostate which, in removal, have opened along the anterior commissure (see Fig. 284)—to which category the great majority belong—will show that the dilated portion of the prostatic urethra,

viz. that portion lying between the verumontanum and the vesical outlet, has come away with the prostate, the urethra in front of this being left behind. The portion of the urethra behind the point at which the ejaculatory ducts enter it is much more adherent to the prostate than that in front of it, between this point and the triangular ligament. In fact, in the greatly enlarged prostate this latter portion lies quite loosely attached to the lobes on either side. When a prostate is enucleated in its capsule from the sheath all round, and the lobes are gently separated from the triangular ligament by the point of the finger, the organ can be felt hanging on by the urethra and the ejaculatory ducts, and the finger-tip can be easily inserted on either side between the inferior portion of the prostatic lobe and the urethra. If now the finger-tip be placed behind the prostate in the median line above the ejaculatory ducts, and the prostate be propelled upwards into the bladder by the finger in the rectum, the urethra will be found to snap across at the verumontanum, leaving the ejaculatory ducts, as a rule, adherent to the portion of the prostatic urethra left behind.

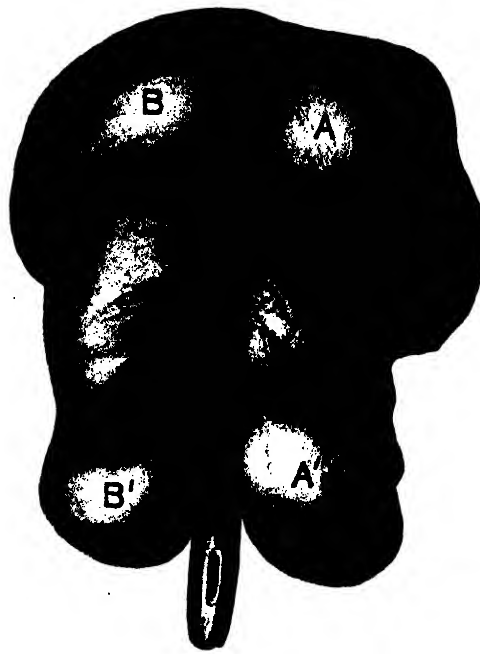


FIG. 285. ENUCLEATED PROSTATE. Showing right, A, and left, B, lobes covered by a thin layer of the sheath, and outgrowths A', B', in the bladder from these lobes respectively.

Toilet of the wounds. With the delivery of the prostate from the bladder the essential part of the operation may be regarded as completed. The forefinger of one hand is reintroduced into the bladder forthwith, and that of the other hand into the rectum. The opposing surfaces of the cavity, from which the prostate has been enucleated, are then pressed together all round the vesical orifice between the tips of the fingers. By thoroughly kneading the opposed surfaces together in this manner the contraction of the cavity, and its diminution in size, are facilitated, and hæmorrhage is thus arrested, just as a dentist presses the gums together after the extraction of a tooth, or the accoucheur does the flaccid womb after parturition, with a similar object in view.

The bladder is then irrigated with hot boric lotion (temperature about 110° F.) through the catheter still *in situ*, for the purpose of removing clots, and, further, to control bleeding. This process should not, however, be continued for more than two or three minutes, as I find from experience that these irrigations not infrequently promote bleeding, instead of diminishing it, if the irrigation be continued too long.

FIG. 286. PROSTATECTOMY DRAINAGE TUBE. Actual size.

The bladder having been cleared of clots, and whilst the irrigation is still proceeding, a stout india-rubber drainage tube is introduced through the suprapubic wound. The dimensions and management of this tube I regard as of the utmost importance in the after-treatment of this operation. I have been gradually increasing the calibre of this tube, till I now invariably employ $\frac{7}{8}$-inch tubing, with a lumen of $\frac{5}{8}$ inch in diameter. Two large perforations or eyes are made as near as possible to the vesical end of thist ube (see Fig. 286), on opposite sides of it. Only about 1 inch of the tube should project into the bladder, just sufficient for the side openings to lie completely within its cavity. When the bladder is allowed to contract, the tube is gripped by it, so that the whole of the urine escapes through the tube. In this way infection of the loose tissues in the prevesical space is obviated and cellulitis prevented. On no account should the tube be inserted into the prostatic cavity, our object being to facilitate by every means the contraction of this cavity. If more than 1 inch of the tubing be introduced into the bladder, it will press on its base and give rise to constant straining, and pain in the end of the penis like that caused by vesical stone.

The edges of the parietal wound are now brought together around the tube by silkworm-gut sutures, one or two of which should pass deeply through the recti muscles. On no account should buried sutures be employed, as they are certain to be infected by the urine. One of the sutures should pass through the drainage tube to keep it securely in position. No sutures are inserted in the bladder.

Before withdrawing the catheter and applying the dressings the bladder is once more irrigated, in order to remove clots and ascertain that drainage is quite free. Finally, a couple of inches of broad iodoform-

gauze tape are inserted in one angle of the wound against the side of the tube, and left there for twenty-four hours. This is done for the purpose of preventing the accumulation of fluids in the prevesical space. The wound is now covered with cyanide of zinc gauze, and the patient deeply swathed in absorbent dressings—front, sides, and back. The whole dressing is kept in place by a broad flannel binder or many-tailed bandage, loosely applied. Cotton-wool, wood-wool tissue, or cellulose may be employed. The last is most absorbent and keeps the patient driest ; but a thin layer of cotton-wool should be placed between it and the skin ; otherwise the cellulose, when wet, forms a pulp, which adheres to the skin and feels cold and clammy.

After-treatment. The dressings should be changed when saturated with urine, every four or six hours, according to the quantity of fluid secreted. During the first twenty-four hours after operation there will generally be some clots of blood lying in the drainage tube ; these should be removed by long slender forceps at each dressing.

The bladder should be irrigated once daily by the surgeon himself, with warm boric lotion or a weak solution of permanganate of potash. For this purpose a long glass nozzle attached to the rubber tubing of an irrigating can is best, the nozzle being introduced through the drainage tube. During the first few days there should be very little pressure of fluid on the bladder, the irrigating can being held, or placed on a table, a little above the level of the patient's abdomen, so that the lotion flows into the bladder and out again through the drainage tube with very little force. It is all-important that in the early days the drainage should be thoroughly free, and that no pressure should be thrown on the cavity from which the prostate has been removed, either by the accumulation of urine in the bladder or by pressure from a high column of lotion, so that the cavity may remain at rest, and that blood-clot adherent to its surface may be undisturbed, thus obviating bleeding and facilitating the healing process. This is the main object with which I employ such a stout drainage tube—that the urine and clots may escape through it freely, and that, consequently, there may be no straining, which would have the effect of dilating the cavity. Patients who pass no urine *per urethram* for ten or twelve days after operation almost invariably do best.

The patient should lie on his back for twenty-four hours, after which he should be placed alternately on either side, and on his back. During the first four or five days he should not be allowed to make any exertion, all movements being effected by nurses. Should there be any oozing of blood after the operation, the foot of the bed should be raised on blocks and hypodermic injections of ergotin given. Shock, when it occurs immediately after operation, should be treated by warmth from hot-

water bottles, extra clothing, hypodermic injections of strychnia, and enemata of coffee and brandy. Pain or spasms of the bladder should be relieved by hypodermic injections of morphia. Should there be any bronchial catarrh or other lung affection, the patient's head and shoulders should be well raised by pillows after the first twenty-four hours succeeding the operation. And in any case this position should be encouraged early, so as to obviate hypostatic congestion of the lungs.

As a rule, I remove the large tube four days after operation. If the patient be thin, the tube may be dispensed with in three days; if he be very stout, it should be left in for five days. By this time plastic lymph will have been thrown out round the tube, thus shutting off the prevesical space from contact with the urine and in this way avoiding the occurrence of cellulitis. Before removal of the large tube a smaller tube should be passed through its lumen and left in the fistula for a few days, to facilitate free drainage from the bladder, the wound in which may then be allowed to close as rapidly as nature can accomplish this by granulation.

The sutures are removed on the seventh or eighth day, by which time primary union will have taken place in the parietal wound, save, of course, in the track of the tube.

Irrigation of the bladder must be continued daily—twice daily, if the urine be at all foul—by inserting the long glass nozzle of the irrigator through the fistula right down into the viscus. The return stream will in the early days flow out beside the nozzle; but as the fistula contracts the nozzle will fill it; and the irrigation is then accomplished by alternately filling the bladder with the lotion and then withdrawing the nozzle, when the fluid will rush out with more or less force. As the case advances more and more pressure on the bladder may be employed. The irrigation should be continued till the boric lotion returns quite clear, or the permanganate lotion unaltered.

After nine or ten days from the operation Janet's method of irrigation may be employed, if possible. This consists in introducing the glass nozzle into the urethra and gradually raising the irrigating can till the column of fluid forces the lotion into the bladder and out through the suprapubic opening. This is, perhaps, the best method of flushing out the bladder; but some patients will not tolerate it, owing to the pain produced. It should never be employed during the first week after operation for fear of causing bleeding; and if it cause pain it should not be employed at all. Patients vary much in their tolerance of this method of irrigation.

After a fortnight or so, when the bladder is distended by lotion through the nozzle placed in the suprapubic opening, the patient will

frequently pass the lotion *per urethram* as rapidly as it enters the bladder. When this takes place, it is an effectual method of flushing out the bladder.

It will be observed that I have not hitherto referred to the employment of the catheter for the purpose of washing out the bladder during the after-treatment. In the early days after the introduction of this operation I was in the habit of introducing a large-sized gum-elastic catheter through the urethra daily after the third or fourth day from the operation, and irrigating the bladder through this. The catheter was introduced partly in consequence of my apprehension that, if it were not thus employed, there might be contraction of the deep urethra during healing of the prostatic cavity. Experience has, however, taught me that my apprehension in this respect was quite unfounded, for in not a single instance has there been any contraction to interfere with the free flow of urine. I do not now introduce a catheter till the suprabubic fistula has contracted to such narrow dimensions that it will not admit the nozzle, so that irrigation cannot be practised in this way. It is employed only during the few days before the patient begins to pass urine *per urethram* in volume, in order to keep the bladder clean during this transition period. When once natural micturition is established, the bladder is, of course, automatically flushed out.

The management of the bowels is of the utmost importance. For three or four days previous to the operation the bowels should be freely moved once daily at least, by means of a laxative pill given at night and a mild saline in the morning. On the morning of the operation the lower bowel should be emptied by means of an enema. The bowels should then be left undisturbed for two or three days, when they should be freely moved by castor oil or liquorice powder, or any drug that can be depended on to act with certainty and efficiency. After this the bowels should be moved gently once a day by means of a pill taken at night or a saline in the morning, or both if necessary. Patients of the prostate age confined to bed are liable to the accumulation of fæces in the rectum forming a hard mass, owing to the want of tone in the bowel. The occurrence of this is attended by much discomfort and spasm of the bladder from pressure thereon, and this must be guarded against. Should its presence be suspected, a finger should be introduced into the rectum, the mass broken down, and removed by an enema.

Patients should, as a rule, be confined to their rooms, but not necessarily kept in bed, for three or four days before the operation. Poor, broken-down hospital patients will require to be kept under observation for several days at least, in order that they may be fed up, and their general health improved before operation.

I have entered somewhat at length into the details of the after-treatment, because I consider that an intelligent appreciation of, and attention to, them is not less essential to success than the skilful performance of the operation.

Secondary hæmorrhage. Secondary hæmorrhage has occurred in a few instances. It is a very rare sequela of the operation, but has to be dealt with occasionally.

Slight arterial hæmorrhage may occur from the suprapubic wound on removal of the large drainage tube on the fourth or fifth day. This is purely traumatic and due to the fact that the tube is gripped by the bladder. The utmost gentleness should be employed in removing the tube, which should be withdrawn slowly, and with a slight rotatory movement, should it be gripped very tightly by the wound. The bleeding from this cause is always trifling, and automatically ceases in a short time.

Should there be any obstruction to the free flow of the contents of the bladder through the tube during the early days after operation, the prostatic cavity is liable to be dilated, resulting possibly in venous hæmorrhage from its walls. This is controlled by readjusting the tube in such a manner that free outlet is given to the urine, and by irrigating the bladder through the tube with boric lotion as hot as the patient can bear.

But the most serious form of hæmorrhage takes place, strange to say, in the case of patients in whom the healing process is most rapid, resulting in the suprapubic wound closing earlier than usual. Urine is then passed *per urethram* before the prostatic wound is sufficiently healed to bear the resultant pressure on its surface, and hæmorrhage may take place owing to spasm of the bladder and the consequent undue pressure on the prostatic cavity. Should this occur, a full-sized rubber or gum-elastic catheter should be introduced through the urethra and tied in the bladder, so as to give free exit to its contents.

But should the hæmorrhage persist, giving rise to pain and spasm from the accumulation of clots in the bladder, no time should be lost in reopening the suprapubic wound, and in reinserting a large drainage tube for a few days, to relieve the pressure on the walls of the prostatic cavity. Hypodermic injections of ergotin and the administration by the mouth of calcium chloride should also be employed.

CHAPTER XVI

PERINEAL PROSTATECTOMY: OPENING A PROSTATIC ABSCESS

CONCURRENTLY with the introduction and development of suprapubic methods of removing the enlarged prostate numerous procedures have been devised for its excision by the perineal route.

DITTEL'S OPERATION

The earliest suggestion in this direction came, I believe, from van Dittel in the years 1880–90. His operation consisted in removing a wedge-shaped portion from the under surface of one or both lobes of the enlarged prostate with a view to relieve the pressure on the urethra. This was accomplished through an incision extending from the median raphé round the sphincter ani to the tip of the coccyx. The ischio-rectal fossa was opened up, and by dissection the rectum was separated from the prostate, which was exposed, and a wedge-shaped portion removed from one lobe. By extending the dissection in front a little beyond the middle line the other lobe could be exposed and similarly dealt with. An essential feature was that the bladder and urethra were left intact.

This operation does not appear to have been performed in many instances, and the records of cases were not very encouraging, fistulæ remaining in some of them owing to the urethra or bladder having been opened during the procedure, and imperfect results being obtained in others.

NICOLL'S OPERATION

Nicoll modified this operation by performing a preliminary suprapubic cystotomy. This was done for the purpose of introducing one or two fingers into the bladder with a view to pushing the prostatic tumour into the perineal wound, thus facilitating its removal, and at the same time obviating the opening of the mucous membrane of the bladder or urethra.

Alexander's operation. The procedure adopted by Alexander was somewhat similar to that of Nicoll, except that the urethra was opened on a staff and a perineal tube inserted for drainage of the bladder.

GOODFELLOW'S OPERATION

The patient being placed in the lithotomy position and a staff introduced, a median incision is made in the perineum from the base of the scrotum to the margin of the anus and carried down to the membranous urethra, which is entered by a lithotomy knife, and the opening extended to the neck of the bladder. The staff is then withdrawn and the finger introduced. With the tip of the finger the prostatic lobes are enucleated, commencing at the perineal aspect of the gland and working up towards the bladder, and removed through the perineal wound. The prostatic urethra is necessarily removed with the gland. No drainage tube is inserted, the urine being allowed to flow through the wound. Formerly Dr. Goodfellow passed a catheter through the wound every second day for a week or so to keep up free drainage, but latterly this practice has been abandoned, neither irrigation nor the passage of a catheter being permitted, and the cases are said to do as well as or even better than under the older practice.

PROUST'S OPERATION

In 1901 perineal prostatectomy received a marked impetus owing to the practical and lucid description of the operation given by Proust, of Paris, in the October issue of the *Presse Médicale*, subsequently elaborated in his work *Prostatectomie périnéale*. This operation, with modifications by various surgeons, was largely practised on the Continent in the years immediately following, and is so still in America, the most enthusiastic exponents being Albarran in France and Young in America. During the last three or four years, however, this operation has been undergoing a gradual displacement by the writer's operation of suprapubic enucleation, termed in France 'prostatectomie transvésicale'. Perineal prostatectomy has never been at all largely practised in this country.

Proust's operation is as follows: The bladder having been washed out, a staff is introduced. The patient is then placed in the 'inverted perineal position'. By means of a metal framework attached to the operating table the patient's legs are held vertically and the thighs horizontally. The buttocks are raised on an inclined plane, so that the sacrum is almost vertical and the perineum directed upwards towards the ceiling of the room. The staff is held by an assistant so as to lift the urethra towards the pubic arch and thus avoid its being opened during the preliminary dissection of the perineum.

A concave incision, with its convexity forwards (see Fig. 287), is carried

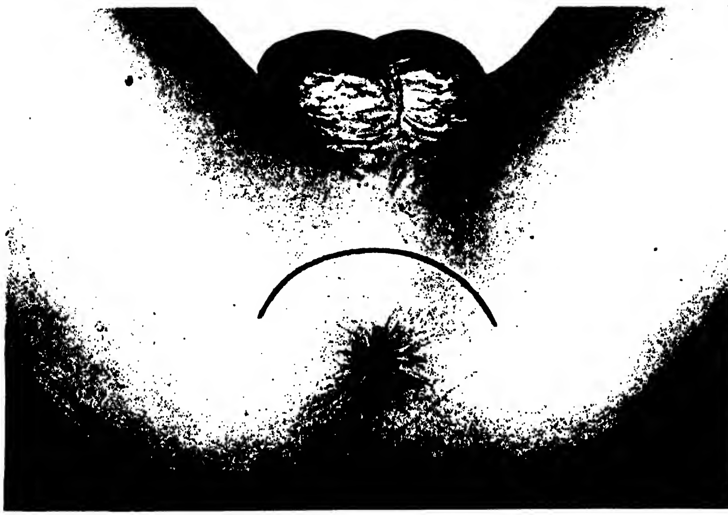


FIG. 287. THE SUPERFICIAL INCISION IN PERINEAL PROSTATECTOMY. (*Proust.*)

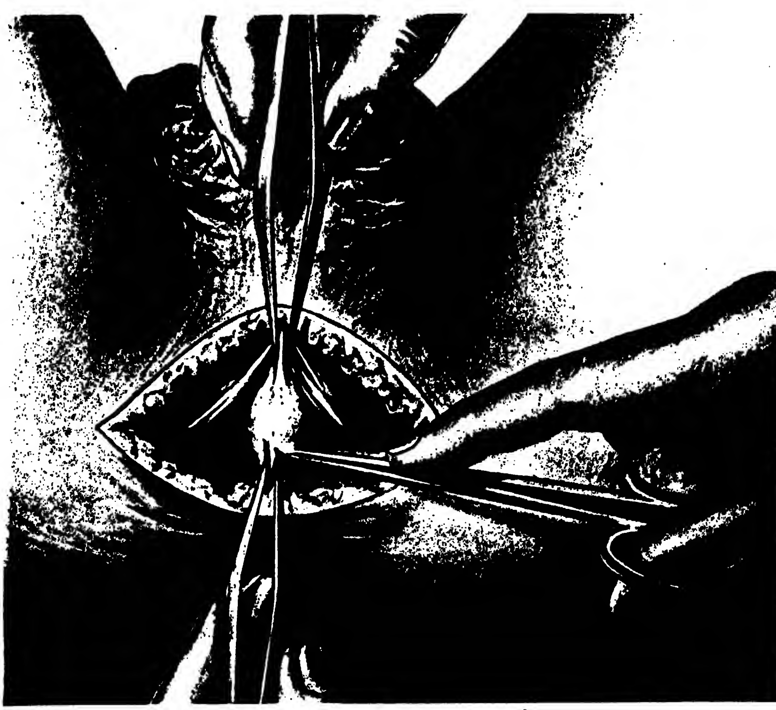


FIG. 288. SECTION OF THE RECTO-URETHRAL MUSCLES. (*Proust.*)

through the skin and subcutaneous tissues across the perineum to the ischium on either side, at a distance of two fingers' breadth from the anus. The external anal sphincter then comes into view behind, and the bulb, covered by the bulbo-cavernosus muscles, in front. The median fibro-muscular band uniting them (the ano-bulbar raphé) is then divided transversely. When the bulb is drawn forwards by forceps the posterior margins of the transverse perineal muscles are clearly defined.

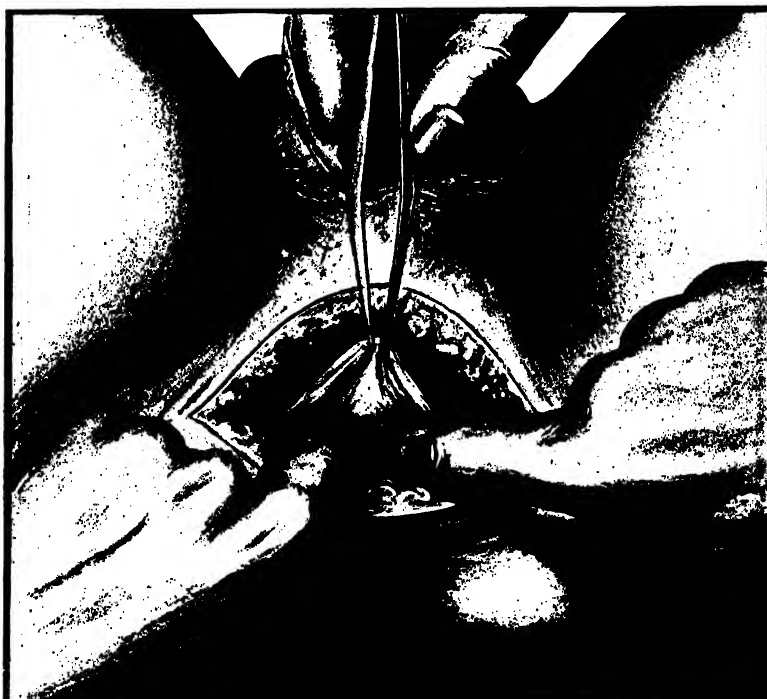


FIG. 289. THE TISSUES PUSHED ASIDE BY THE FOREFINGERS TO BRING THE PROSTATE INTO VIEW. (*Proust.*)

The bulb being still pulled forwards the posterior lip of the wound is drawn backwards, when the recto-urethral muscles, passing from behind forwards, come into view, and on either side the anterior margins of the levator ani muscle passing up behind the triangular ligament. Pushing the levatores ani aside by the fingers, the recto-urethral muscles, which draw the rectum forwards, are divided close to the transverse ligament (see Fig. 288).

The rectum then falls away backwards, and the apex of the prostate appears. Introducing the forefingers into the wound the tissues are

pushed aside (see Fig. 289) and the smooth posterior aspect of the prostate, covered by its sheath, or outer capsule, is brought into view. If the various incisions have been properly carried out there will be scarcely any bleeding. A broad duck-bill retractor is now introduced in the posterior portion of the wound and the rectum is drawn forcibly backwards, when the prostate comes more fully into view.

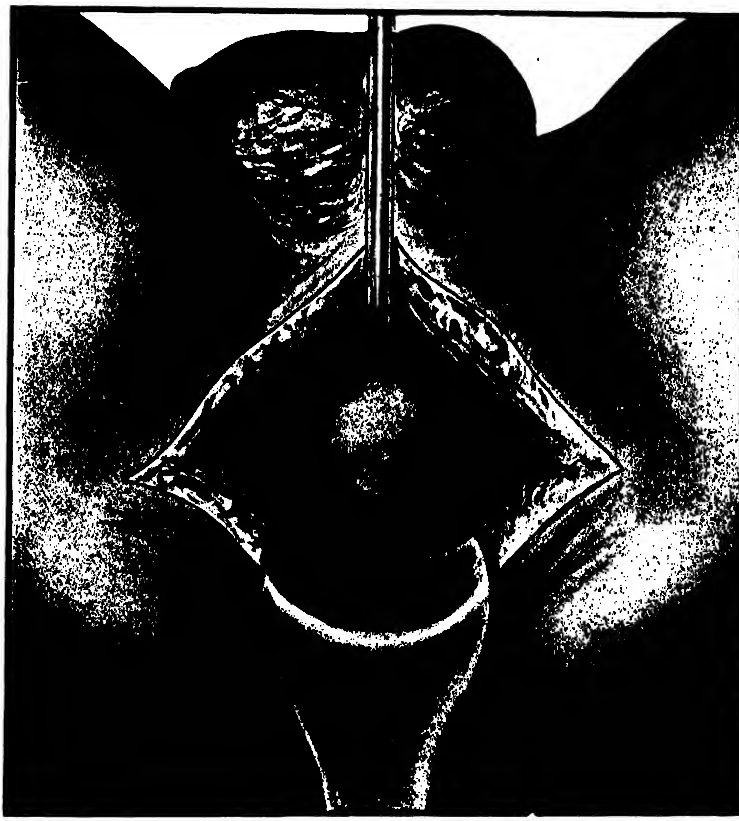


Fig. 290. Prostate made to protrude in the Wound by means of the Depressor. (*Proust.*)

The urethra is then opened on the staff at the apex of the prostate. Proust lays stress on opening the prostatic rather than the membranous urethra. The margins of the mucous membrane are caught by forceps or ligatures and drawn aside, and the 'depressor', or 'tractor', is introduced through the wound after the sound has been withdrawn. The arms of the depressor are opened and the neck of the bladder fixed by them. The instrument is then consigned to an assistant, who by this

means pushes down the prostate and makes it protrude in the wound (see Fig. 290). Two strong catch-forceps are then applied to the sheath, one on either side of the urethra, and by means of scissors and a blunt dissector the sheath is peeled off the prostate (see Fig. 291).

The internal separation of the prostatic lobes from the urethra is then commenced. By enlarging the urethral opening backwards as far as

FIG. 291. BISECTION OF THE PROSTATE AND OPENING OF THE URETHRA. (*Proust.*)

the neck of the bladder, which, however, should not be incised, the prostate is bisected. The forefinger of the left hand is introduced through the wound as a guide, and each lobe is in turn separated from the urethra by scissors (see Fig. 292), a blunt dissector, and the forefinger of the right hand, a sufficient thickness of prostatic tissue being left to support the urethra. During the process of ablation of the lobes the tractor is used to depress them in turn into the wound, and strong catch-forceps are also brought into use to pull them to the surface.

Pediculated outgrowths of the prostate in the bladder are made to

protrude through the urethral wound by hooking them down by the finger, when they are torn away or cut off by scissors. Broad-based masses are pushed by the finger, introduced into the bladder, into the wound on either side, and removed like the lateral lobes, care being taken that the mucous membrane of the bladder is left intact.

The exuberant portions of the urethra, which is, as a rule, greatly enlarged and distorted out of shape, are clipped off, sufficient membrane,

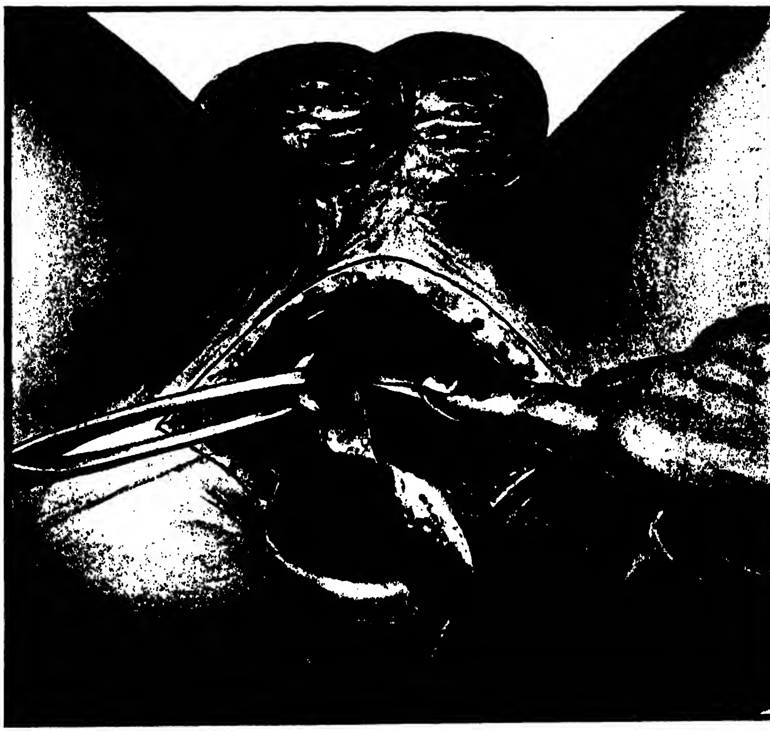


FIG. 292. DISSECTION OF THE PROSTATIC LOBES FROM THE URETHRA. (*Proust.*)

however, being left to loosely cover a staff introduced through the urethra. The margins of the urethra are then brought together by several catgut sutures, commencing at the vesical extremity of the wound, sufficient room being left in front for the insertion of a drainage tube into the bladder on the withdrawal of the staff. A catheter is also introduced into the bladder through the penis and fixed in position, not for the purpose of carrying off the urine, which flows through the perineal tube, but for periodic irrigation of the bladder.

The levatores ani and adjacent structures are now brought together by one or two deep catgut sutures; strips of gauze for drainage purposes

are placed in the perineal wound, and the posterior skin flap is brought forward and kept in position by sutures on either side, the central portion, through which the gauze strips protrude, being left open. Dressings are then applied and held in position by a broad T-bandage, pressure being mainly exerted between the coccyx and the anus, so as to bring the rectum in apposition with the bladder and urethra in the deep portions of the perineal wound.

The urine is conducted from the perineal tube to a pail beneath the bed by means of rubber tubing. The bladder is irrigated twice daily, and the dressings changed every day after the second. The perineal tube is removed after a week, but the catheter is left in, being changed from time to time as it requires cleansing or renewal, till the perineal wound is completely closed, during a period which is estimated at from three to five weeks, when the urine is allowed to pass naturally through the penis.

Albarran's modification. Albarran advocates the removal of the lobes *par morcellement* instead of each lobe being removed entire, and Proust admits that in some cases, particularly when the prostate is friable, this piecemeal ablation of the gland is necessary.

YOUNG'S OPERATION

Young follows mainly in the lines laid down by Proust, but introduces certain modifications in the procedure, the most important of which are these: (1) The preliminary perineal incision is in the form of an inverted V. (2) The membranous urethra is opened for the introduction of the 'tractor', and, later on, the insertion of the drainage tube, an attempt being made to leave the prostatic urethra intact in the course of removing the prostate. (3) He endeavours to preserve the ejaculatory ducts intact, by leaving behind a central wedge of the prostate. For this purpose, after exposure of the posterior surface of the prostate, 'an incision is then made on each side of the median line for almost the entire length of the posterior surface of the prostate and about 1·5 cm. deep. The two lines are divergent, being about 1·8 cm. behind and 1·5 cm. apart in front. The bridge of tissue which

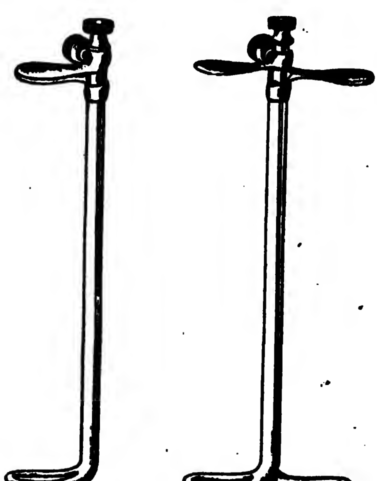


FIG. 293. YOUNG'S PROSTATIC TRACTOR OR DEPRESSOR.

lies between them contains the ejaculatory ducts, and its preservation is of importance if the integrity of these non-obstructive structures is to be left uninjured. It is for this purpose that I make the initial capsular incisions 1·5 cm. deep on each side, and these define at once, and correctly, the width of the ejaculatory bridge, and prevent its being torn, as might happen if we depended on blunt dissection' (Young). (4) A double catheter is introduced into the bladder through the wound in the membranous urethra, for continuous irrigation, and fixed there by a suture. This is removed after twenty-four hours, and the urine allowed to flow through the perineal wound till it heals by granulation. (5) The lateral cavities are lightly packed with gauze, which is removed after twenty-four hours, and no further packing is introduced.

BOTTINI'S OPERATION

Division of the prostatic bar or outgrowth by means of the galvanic cautery was introduced by Bottini of Pavia. An electrode shaped somewhat like a Mercier's sound is introduced into the bladder through the urethra. The beak is turned round and the instrument is withdrawn till it impinges against the obstruction. The current is then turned on and the obstructing portion of tissue is burnt through.

This operation, though still practised in America and Germany, has never come into vogue in this country. It is applicable to only a very limited proportion of cases, in which the obstruction is confined to a median outgrowth, or prostatic bar extending across the floor of the orifice of the urethra. It is difficult, with one's present knowledge of the shapes and sizes assumed by the enlarged prostate, to understand how this operation can be of any permanent value. It is attended by considerable danger, as, being done in the dark, it is impossible to gauge accurately the extent of the destruction of tissue due to the cautery.

THE RESULTS OF PROSTATECTOMY

I have now completed 600 cases of the operation of total enucleation of the prostate for enlargement of that organ, the patients ranging from 48 to 89 years, with an average age of 68½ years, the prostates varying from ½ to 16¾ ounces, with an average weight of about 2½ ounces. The great majority of the patients have been entirely dependent on the catheter for periods up to 24 years. Nearly all were in broken health and many apparently dying before operation. Existence was simply unendurable to most of them. Few were free from one or more grave

complications, such as cystitis, stone in the bladder, pyelitis, kidney disease, diabetes, heart disease, chronic bronchitis, paralysis, single, double, and even treble hernia, and in some few instances there was malignant disease of some other organ than the prostate. Such were the unfavourable circumstances under which the operation was undertaken.

In connexion with these 600 operations there were 37 deaths in periods varying from 6 hours to 37 days after operation, or a mortality of 6·15 %. The mortality has been steadily decreasing from 10 % in the first 100 cases to 4 % in the last.

The causes of death were: uræmic symptoms due to chronic kidney disease, 16; heart failure, 6; septicæmia, 2; shock, 3; exhaustion (kidneys were extremely diseased), 1; mania (hereditary in 1), 2; malignant disease of liver, 2; heat stroke, 1; pneumonia, 1; acute bronchitis, 1; pulmonary embolism, 1; and cerebral hæmorrhage with paralysis, 1.

Though all these deaths are accepted in connexion with the operation, in not more than one-half the number can the fatal result be attributed thereto, the remaining deaths being due to diseases incident to old age and unconnected with the operation.

In 108 cases vesical calculi were removed at the same time, but all the deaths in these cases are accepted in connexion with the prostatectomy operation, none being put down to the suprapubic lithotomy involved.

The mortality from perineal prostatectomy is constantly stated to be less than that from suprapubic enucleation of the gland. This may have been the case in the early history of the operations, say from 1900–5; but I do not think that this has been the case in recent years, when the latter operation has been performed on the lines laid down in my writings.

No real comparison can, however, be instituted between the mortalities attending the two operations, for the simple reason that, as the records of cases show, the types of patients dealt with are not similar,—the ages being more advanced (I have operated upon 47 octogenarians between 80 and 89 years, and 9 aged 79 years), the prostates much larger, and, as a rule, the general conditions of the patients more unsatisfactory in cases submitted to suprapubic enucleation than in those operated upon by perineal prostatectomy.

The success attending suprapubic enucleation means an absolute cure, the patient regaining the power of retaining and passing urine naturally without the aid of a catheter as well as he ever did. There is no relapse of the symptoms, no contraction at the seat of operation

leading to stricture, and no fistula remains. Further, there is no diminution in the sexual power.

Can perineal prostatectomy be said to be followed by similar good results? Though I have no personal experience of this operation on modern lines, my observations on patients operated upon by others, the printed records of cases, and conversations I have had with many Continental and American surgeons lead me to answer emphatically in the negative. The success attending perineal prostatectomy in a large proportion of the cases is not a cure at all, but at most an amelioration of the pre-existing conditions, and frequently not even that. Perineal prostatectomy is frequently followed by recto-vesical, recto-perineal, and uro-perineal fistula; incontinence of urine, temporary as a rule, but sometimes permanent; frequency of micturition, due to residual urine; stricture requiring the frequent introduction of sounds; and complete loss of sexual power—a very grave drawback when dealing with men sometimes scarcely beyond the prime of life.

Perineal prostatectomy is, indeed, not a complete prostatectomy at all; and one of the gravest dangers of leaving a portion of the gland behind (designedly in Young's operation) is the liability of adenomatously enlarged prostates to degenerate into cancer as life advances, a liability which such an able surgeon and keen observer as Pouchet of Amiens puts down at 10%.

EVACUATION OF A PROSTATIC ABSCESS

A prostatic abscess should be opened at the earliest moment after its presence has been definitely diagnosed, for it may rapidly increase in size, destroying one or both lobes of the organ, and burst into the urethra, the rectum, or the ischio-rectal fossa.

Operation. The perineum having been shaved and purified, the patient is anæsthetized and placed in the lithotomy position. The forefinger of the left hand is introduced into the rectum, its palmar surface being directed forwards and its tip resting on the prostate at the point where fluctuation is most distinct. The point of a long stout scalpel is then introduced in the median raphé of the perineum 1 inch in front of the anus, and pushed onwards in the direction of the tip of the finger placed in the rectum, and then, as it is withdrawn, the external incision is enlarged. Sinus forceps are then passed through the wound as far as the abscess and the jaws opened. When pus begins to flow, the forceps being withdrawn, the forefinger of the left hand, previously purified, is passed through the wound, the opening into the abscess is enlarged, and all septa are broken down. A stout drainage tube is then introduced

into the depth of the abscess cavity, which is thoroughly irrigated with an antiseptic lotion. The tube is fixed in position by a suture in the perineal skin.

Sometimes there is rather profuse bleeding, requiring the cavity to be packed with iodoform gauze round the drainage tube, which in these circumstances should be made of gum-elastic tissue.

If the urethra be opened during the manipulations, it is advisable to pass a perineal drainage tube into the bladder and allow the urine to flow clear of the wound for a few days. The urinary fistula thus formed will soon close as granulation of the wound proceeds.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART V

OPERATIONS UPON THE URETHRA

BY

J. W. THOMSON WALKER, M.B., C.M. (Edin.), F.R.C.S. (Eng.)

Assistant Surgeon to St. Peter's Hospital for Stone and other Urinary Diseases

CHAPTER XVII

URETHROSCOPY: OPERATIONS UPON THE URETHRAL MUCOUS MEMBRANE: REMOVAL OF URETHRAL CALCULI

URETHROSCOPY

In the instruments at present in use, electric light is the invariable luminant, and it is used in one of two methods—either directly, the lamp being placed at the inner end of the urethral tube, or reflected from a lantern fixed to the outer end of the tube. The former variety gives a very bright illumination, but is open to the objections that the lamp tends to become overheated during a prolonged examination, and may scorch the urethral mucous membrane, that application of fluids to the mucous membrane can only be made after withdrawing the lamp, and that the lamps are very small and sensitive, and are quickly destroyed by variations in the electric current and require frequent renewal.

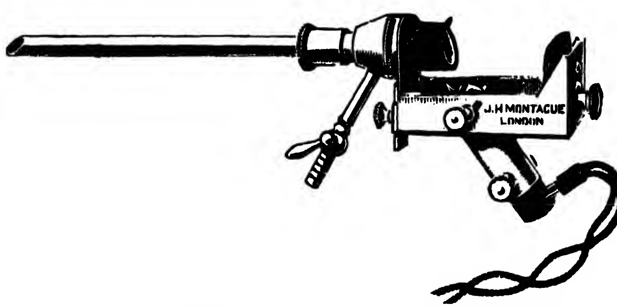


FIG. 294. WYNDHAM POWELL'S URETHROSCOPE.

The various modifications of the Leiter principle of a fixed lantern from which light is reflected along the urethral tube are more serviceable, and if well made and carefully regulated give an equally good illumination.

To this form of urethroscope the air-distension apparatus originally introduced by von Antal is fitted. The modification by Dr. W. Wyndham Powell is a useful instrument (see Fig. 294).

There is a square lantern-box in which a powerful electric lamp is set obliquely. Immediately above the light is a movable lens which concentrates the rays upon a small reflecting mirror at the upper end of the box. This mirror directs the light into the nozzle which fits into the upper end of the urethral tube. The nozzle is closed at its upper end by a glass window which springs open on releasing a small catch. A tube provided with a stop-cock enters the nozzle laterally, and is connected

with a rubber bulb which supplies the air-pressure. The rubber bulb should be the size of a melon, in order to give air-distension during a prolonged examination. A segment is cut from the circumference of the reflecting mirror, so that the operator's gaze, directed over the edge which corresponds to the cord of the segment, falls closely parallel with the rays of light which project into the urethral tube. Another handy form of urethroscope is made by Schall (see Fig. 295).

The urethral specula are five inches in length, and of different calibre (see Fig. 296). Nos. 23 to 26 Charrière are useful sizes. The distal end of the tube may be cut obliquely or transversely, the former giving a slightly larger field. An obturator fills the lumen of the tube during the insertion into the urethra, and is removed when the required depth is reached. The distal end of the tube must be smoothly rounded, that it may not lacerate the delicate mucous membrane of the urethra.

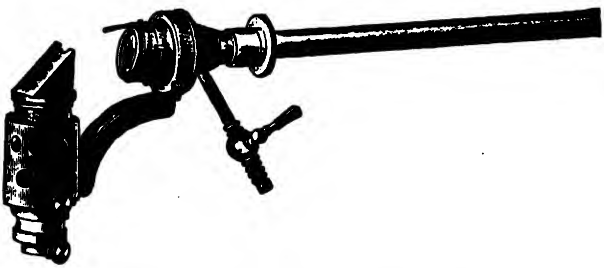


FIG. 295. SCHALL'S URETHROSCOPE.

FIG. 296. URETHRAL SPECULUM.

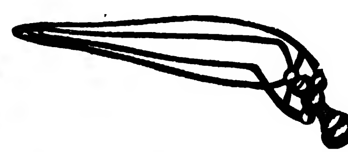


FIG. 297. SMITH'S URETHRAL SPECULUM.

The obturator must fit accurately, and there should be no abrupt shoulder at its junction with the tube.

An inverted cup may be provided at the prominent end of the tube, and receives the glans penis. It is supposed to prevent the escape of air when the urethra is inflated, but it is unnecessary. The tubes may, for convenience of noting the position of diseased portions of the urethra, be marked in half-inches. It is convenient to have one or two short tubes (2 to 2¼ inches long) for examination of the outer portion of the penile urethra. A wire speculum (Smith's) (see Fig. 297) or the slightly more elaborate speculum of Watson may be used with reflected light for examination of the first inch or so of the urethra. For examination of the prostatic urethra a longer tube (6¾ inches) with a beak (1 inch) set at an angle to the shaft should be used (see Fig. 298). An open

window is situated at the convexity of the junction of beak and shaft. The lumen is filled by an obturator during introduction. When the tube is in position it displays the verumontanum and surrounding parts of the floor of the prostatic urethra.

The urethroscope is used in the following manner: The canula and metal obturator are boiled before use. The instrument is lubricated with sterile olive oil. The patient is recumbent on a high couch with the surgeon standing on his right side, or he may occupy an examination chair with the legs well flexed, and the surgeon sits between the widely separated knees. The penis is grasped with the left hand so that the second and third fingers lie behind the corona glandis, leaving the first finger and thumb free to manipulate the meatus and to support the tube and urethroscope after it is introduced. The penis is held erect and the tube gently introduced. During the introduction any points of special tenderness are noted, and if the instrument hitches it should not be forced onwards, but the examination commenced from this spot. Not infrequently the passage of the instrument is interrupted at the peno-scrotal angle, but by bringing the tube nearer the long axis of the body it glides onwards.

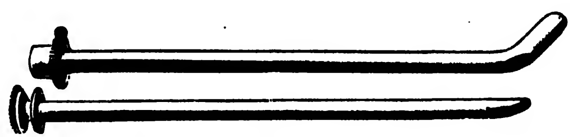


FIG. 298. SPECULUM FOR THE PROSTATIC URETHRA. The obturator is shown below the tube.

It should pass on without actual obstruction to the hilt. The thumb and forefinger of the left hand grasp the flange of the canula, the obturator is withdrawn, and a urethral sponge on a holder gently run down the tube to mop up the lubricating fluid. This is withdrawn and the urethroscope fitted on to the tube. The rubber balloon has previously been inflated and the stop-cock and glass window closed.

The light is switched on and the urethral mucous membrane examined. The weight of the instrument should be supported by the thumb and first finger of the left hand, which grasp the proximal end of the canula, and the hand is steadied by the fourth finger resting on the pubes.

The mucous membrane of the urethra is pale pink, varying in depth of colour from that of the conjunctiva to that of the inner surface of the lip. It shows fine longitudinal striation due to the direction of the blood-vessels. The bulbous urethra is closed at its inner end by the membranous urethra tightly grasped by the compressor urethræ; examined with the urethroscope, there is a central dimple with radiating folds (from 2–8 in number, usually 5 or 6), each fold showing a longitudinal striation. If a little air is admitted by turning the stopcock the opening will recede, and it

will be seen that the aperture lies on the roof of the bulbous urethra, the floor rising up to meet it. A little more air-pressure will raise the upper or anterior margin of the opening into a sharp ledge which is in the form of an arch, and an over-pressure of air will result in the orifice gaping and then contracting as the deep urethra swallows a gulp of air. Gradually withdrawing the tube, the roof and floor should be carefully examined. A median white ridge may sometimes be seen on the floor of the first inch or so of the bulbous urethra. This indicates the line of the ducts of Cowper's glands, but it is seldom that the openings of these ducts can be seen. Very rarely, inflation of the urethra will open up the orifice of one of these ducts, so that it resembles a pocket or diverticulum.

Withdrawing the tube still further, the openings of the lacunæ on the roof begin to appear. These are seen with or without the aid of inflation. They show fine red points about the size of a pin's head or less. They are frequently round or oval, but may also appear in the healthy state as fine slits. They become more numerous towards the anterior part of the roof of the canal. At the peno-scrotal junction a thick transverse fold appears on the floor which is due to the duplication of the urethra at this point, where it is slung up by the suspensory ligament of the penis. This should not be mistaken for a stricture. It disappears on bringing the penile urethra into the axis of the bulbous urethra and stretching the penis. The urethral wall falls over the end of the urethoscope tube, and a slight dimple is seen in the middle, from which folds radiate outwards. Under air-distension the urethra is converted into a long tunnel, and the tube must be turned up or down or laterally to inspect the walls. High air-pressure leads to a stretching out of the roof of the urethra into shallow depressions with intermediate ridges which form arches when viewed from the front. These fibrous rings are sometimes mistaken for strictures.

At the junction of the fossa navicularis and the penile urethra two lateral folds are frequently seen, and on the roof at this point the opening of the lacuna magna, with a well-marked transverse fold below it, is usually noted.

Examination of the prostatic urethra with the prostatoscope should be reserved for cases where other methods of diagnosis have failed. Ten or fifteen minims of a 2 % solution of cocaine are dropped into the anterior urethra by means of a rubber-topped pipette, and the fluid is massaged back into the prostatic portion. Or the cocaine may be instilled by means of a Guyon's syringe into the deep urethra and a drop or two expressed from the syringe as it is withdrawn through the membranous portion.

The patient is recumbent on a high couch with the surgeon standing

on his right side. The elbowed canula is boiled, and, with the obturator in position, is well oiled and introduced into the urethra. When the beak engages in the membranous urethra the instrument is fully depressed and pushed on into the prostatic portion. Either at this time or before the introduction of the prostatoscope, the pelvis of the patient is raised on a sand-pillow. The obturator is now withdrawn, and the excessive moisture removed by a swab. The lantern is attached, and the light switched on. No air-distension is used in the prostatic urethra, so that the bellows are dispensed with, and the urethroscope window is open. The verumontanum lies in the field, and the opening of the sinus pocularis can be recognized as a dimple at its summit. At the sides of the verumontanum the prostatic sinuses are seen. A puffy swelling and redness of the lips of the sinus pocularis denotes inflammation in that pocket. Small polypi may be observed in the neighbourhood of the verumontanum in some old-standing cases of gleet.

Before withdrawing the prostatoscope the obturator should be replaced, lest the edge of the window lacerate the inframontanal ridge in its outward passage.

OPERATIONS UPON THE URETHRAL MUCOUS MEMBRANE

Open inflamed lacunæ are a source of continual or recurrent gleet. A single lacuna or many may be inflamed. The outlet of the lacuna is sometimes obstructed so that the discharge is retained.

Cauterization of inflamed lacunæ. An efficient method is to tip a fine stiff wire with nitrate of silver by heating it to a white heat and then drawing it across a stick of solid nitrate of silver, and allowing the melted nitrate to run to the end of the wire and solidify there in a fine bead. A large urethroscope tube is passed down to the offending lacuna, and the mucous membrane dried with a pledget of cotton-wool on a holder. A brilliant light is necessary, and the end of the canula is steadied over the required spot. The light of the urethroscope is switched on, and the glass window opened. The fine wire is now passed along the tube down to the orifice of the lacuna, into which it is passed and then withdrawn. A pledget of cotton-wool soaked in salt solution may now be applied to limit the action of the silver nitrate. Several sittings may be required where a number of lacunæ are affected.

Other methods may also be employed. The inflamed lacuna may be touched with a very fine electro-cautery, or electrolysis may be used. A fine platinum wire is introduced into the orifice of the lacuna and connected with the negative pole of a battery. The positive pad terminal is placed upon the thigh. The current is switched on, and in a few seconds

the whitening of the mucous membrane shows that electrolysis is complete.

Incision of inflamed lacunæ. Another method is to pass a very fine probe-pointed knife (Weber's knife, see Fig. 299) into the lacuna and slit it up. A cotton-wool swab damp with nitrate of silver solution (20 grains to the ounce) is then applied, and easily controls any oozing which might conceal other lacunæ which are to be treated in the same way.

In carrying out these delicate manipulations it is difficult to fix the lax urethral mucous membrane and to expose thoroughly the opening of the

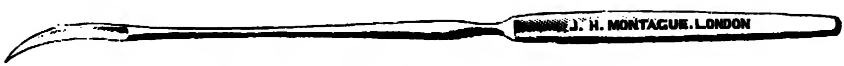


FIG. 299. WEBER'S URETHRAL KNIFE.

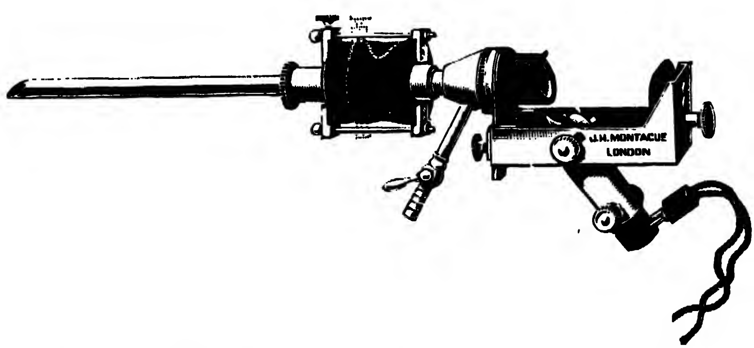


FIG. 300. WYNDHAM POWELL'S OPERATION URETHROSCOPE.

lacunæ, since the urethra must be deflated by opening the window in order to introduce the probe or knife. This difficulty has been overcome by the introduction of an ingenious instrument by Mr. Wyndham Powell, by means of which it is possible to operate in the air-distended urethra under the guidance of the eye. Mr. Powell has given me the following description of his apparatus (see Fig. 300): It consists of a tube of thin rubber 1½ inches in length and diameter, and secured at each end by a metal disk, one disk having in its centre a mount to plug into the urethral canula, and the other a mount to receive the nozzle of the urethroscope. This concertina-like apparatus, which is interposed between the urethroscope and the canula, allows all the necessary movements for intra-urethral instrumentation, while preventing the escape of air. The movements in the longitudinal direction are quite free, except that on collapsing the instrument to project the intra-urethral probe the internal air-pressure has

to be overcome. The other movements are restricted by two side pins which keep the urethroscope more or less in alinement with the canula, from which it is separated by the pneumatic mount. Inside the nozzle of the urethroscope is fixed a fine screw, and into this is screwed the instrument (probe, knife, &c.) selected for use. The urethroscope thus forms the handle of the intra-urethral knife, probe, or curette.

The intra-urethral instrument, when screwed into position just before use, must not project beyond the distal end of the canula, or the urethra may be injured before inflation.

Removal of warts and polypi. Papillomata are met with in the anterior urethra in some cases of persistent gleet. There may be a few small warts, or the whole length of the penile urethra may be carpeted with them. They are easily detached from the mucous membrane, and may be removed by seizing them with alligator forceps. The urethroscope tube is passed along the urethra to the deepest of the warts, which is grasped with the forceps and pulled off the mucous membrane with a sharp tug. The tube should be placed so that the wart lies against the edge of the orifice, and the forceps are guided along the side. Oozing of blood quickly obscures the view, and is controlled by the pressure of a pledget of cotton-wool damp with silver nitrate solution (10 grains to the ounce) or suprarenal extract. The tube is gradually withdrawn, removing other warts in the same manner. Usually several sittings are necessary.

FIG. 301. ALLIGATOR URETHRAL FORCEPS.

The warts are sometimes so lightly attached to the mucous membrane that they are shorn from its surface by the passage of a large tube. I had a segment taken out of one part of the circumference of a urethroscopic tube and the edge of the recess sharpened. A single wart may be manœuvred into this recess and mown down by a sudden push of the tube. Ebermann uses a urethroscope tube, the end of which is closed. An oval eye is provided at one side. The wart is manœuvred into this eye, and then a second tube with an open sharp end is passed along inside the first and the wart cut off.

Small pedunculated polypi in the neighbourhood of the verumontanum are removed by alligator forceps (see Fig. 301) passed along a prostatoscope tube and a pledget of wool soaked in silver nitrate solution applied to the base.

REMOVAL OF CALCULI FROM THE URETHRA

FROM THE ANTERIOR URETHRA

The calculus almost invariably lies behind a stricture and a perineal fistula is frequently present also. There may be one or several calculi and they may extend into the prostatic urethra.

Operation. The perineum is prepared and a staff passed into the urethra. Where a large calculus is present the staff will not pass

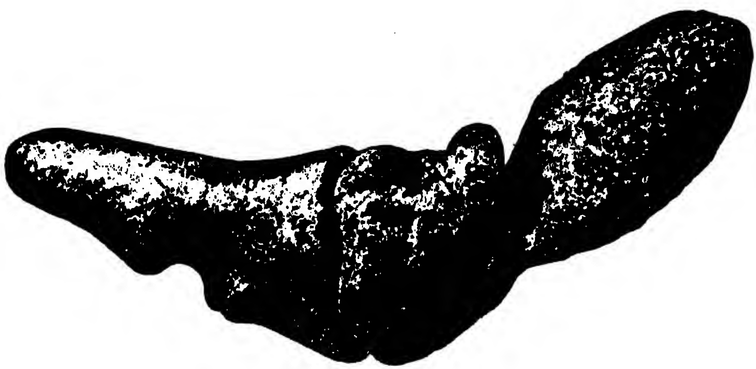


FIG. 302. CALCULI FORMING A COMPLETE CAST OF THE URETER FROM THE VESICAL OPENING TO THE PENILE URETHRA. On the right is a cast of the dilated prostatic urethra separated by a constriction corresponding to the membranous urethra from the dilated bulbous urethra. There was a large perineal fistula at the under surface of the facet between the two calculi. (*Author's case.*)

into the bladder, and if a narrow stricture be present the attempt need not be made.

The patient is placed in the lithotomy position and an incision is made in the middle line over the calculus, which can be felt from the surface. If a fistula be present, this is dissected down to the urethra in the manner described on p. 597 and the urethra opened. Where the fistula is large and direct, the urethra is opened up from this point forwards. The calculus is now grasped in small lithotomy forceps and can be removed without difficulty if it be loose and of moderate size. Sometimes, however, it is adherent to the urethral wall and the mucous membrane must be peeled off it. Where several calculi of large size are present the extraction of one will facilitate the removal of the rest. If the calculus projects into the prostatic urethra, a constriction will be found at the membranous urethra and adds to the difficulty of removing the calculus (see Fig. 302). A curved sharp-pointed bistoury should be passed along the calculus

and the membranous urethra incised at the point of constriction. The gloved forefinger of the left hand is then introduced into the rectum and helps to push out the prostatic portion of the calculus.

The calculi having been removed, a probe director is passed from behind forwards through the stricture behind which they lay and the stricture freely cut upon this. A large steel sound is now passed from the external meatus to ascertain if any narrow part still remains uncut. If it be arrested in front of the external opening in the urethra a urethrotome guide is passed and the constriction severed.

The question of immediate repair of the perineum must now be considered. If the urine be foul and cystitis present, it will be better to tie a large rubber tube in the perineal wound and by this means drain the bladder for some days. After this a catheter should be tied in the urethra and the perineal wound encouraged to heal. If a defect or fistula remains, one of the operations described under the section dealing with these must be performed at a later date.

If the tissues be healthy and the urine not foul, the wound should be closed at the time of the operation by a plastic operation.

FROM THE PROSTATIC URETHRA

Operation. A grooved staff is passed into the urethra, and if it does not pass the calculus in the prostatic portion it will enter far enough to act as a guide for the first part of the operation. The patient is placed in the lithotomy position and the membranous urethra freely opened by a median perineal incision. The right forefinger is introduced alongside the calculus, which is then loosened from its surroundings. This is often a matter of some difficulty, but eventually the finger can be swept round the calculus and a pair of lithotomy forceps fitted upon it and the mass extracted by gradually peeling the soft tissues off it (see Fig. 303).

FIG. 303. URETHRAL CALCULI. Large calculus removed from prostatic urethra and smaller calculus from the bulbous urethra. (*Author's case.*)

After the removal of the stone the large dilated prostatic urethra should be flushed with a copious stream of biniodide of mercury (1 in 15,000) to remove any small fragments. The right forefinger is now pushed through the vesical sphincter and the bladder explored with this and with a sound for calculi. Sometimes the calculus lies in a pocket com-

municating with the prostatic urethra by a small opening through which it projects. The opening must be dilated with the finger and the calculus shelled out. Care should be taken to open the pocket freely into the prostatic urethra after the calculus has been removed.

FIG. 304. RECURRENT URETHRAL CALCULI. Front (above) and side (below) view of two exactly similar calculi removed from a prostato-urethral pouch at an interval of twenty months. (*Author's case.*)

Results. Urethral calculi frequently recur if the precautions given above are not attended to, and sometimes in spite of them. A patient aged twenty-nine years, on whom the writer operated for prostato-urethral calculus and vesical calculus, had undergone sixteen previous operations for stone in the prostate and bladder. The writer removed a prostato-urethral calculus, the exact counterpart of one which he had removed from the patient twenty months before (see Fig. 304).

CHAPTER XVIII

OPERATIONS FOR INJURIES TO THE URETHRA

EXTERNAL URETHROTOMY AND SUTURE OF THE URETHRA IN WOUNDS OF THE PENILE URETHRA

Operation. A bougie is introduced along the urethra and the penis is steadied by an assistant. The skin wound should be extended longitudinally, the sheath of the corpus spongiosum exposed and incised, and the wall of the urethra defined in front and behind the wound. The edges of the urethral wound are trimmed and brought together by fine catgut sutures, so that the closed wound is transverse. The stitches do not pierce the mucous membrane. The sheath of the corpus spongiosum is brought together by a second row of catgut sutures and the skin united by interrupted silkworm-gut sutures, forming a longitudinal wound.

After-treatment. A catheter is retained in the bladder for forty-eight hours and then removed, and a soft rubber catheter passed very carefully three times daily for four or five days, after which time the patient is allowed to pass urine himself. After the operation the rectum is emptied by enema and a suppository containing lupulin (gr. iv), camphor monobromide (gr. iv), and extract of belladonna (gr. ¼), introduced each night to prevent the occurrence of erections, which are sometimes troublesome.

When the urethra is completely severed and the corpora cavernosa remain intact, immediate suture should be carried out on similar lines.

EXTERNAL URETHROTOMY IN RUPTURE OF THE BULBOUS OR MEMBRANOUS URETHRA

Operation. A metal catheter (No. 10) is well oiled and passed gently along the urethra, keeping to the roof of the canal. If the catheter passes the point of rupture and enters the bladder, the urine is drawn off and the instrument kept in position and the patient is prepared for operation. If the catheter does not pass into the bladder, it should be left in the urethra, so that the penile end of the urethra can be identified.

The patient is placed in the lithotomy position. The perineum is

shaved and cleansed. An incision is made into the hæmatoma. If, on attempting to pass the catheter, the rupture be found to lie deeply in the position of the membranous urethra, a curved, transverse, pre-rectal incision with the convexity forward will give the best exposure; but where the rupture lies in the bulbous urethra, and this is the usual position, a median incision is preferable. The fascia of Colles is incised and picked up in forceps on each side and held apart. As this layer is incised, a jet of dark blood which has been pent up usually escapes. The perineal muscles are bruised and infiltrated with blood, and a good head-light is necessary for the further steps of the operation. Any bleeding point is secured and a search for the ends of the urethra commenced. The clots of blood and shreds of lacerated tissue are removed. A stream of hot lotion from an irrigator is useful for this purpose and serves also to control oozing.

If the urethra has not been completely severed, a band of mucous membrane will remain in the position of the roof of the canal. A catheter passed through the penile urethra may be guided along this shred into the membranous urethra and thence into the bladder. There will then be no difficulty in finding the torn edges of the urethra. These are picked up in fine forceps, and the frayed margins are trimmed and united as accurately as possible with catgut sutures.

The metal catheter is replaced by a rubber or gum-elastic instrument, which is secured in position.

If the urethra has been completely severed, the penile end of the canal will be found upon the instrument which was passed from the external meatus. A silk suture is passed through the wall of the canal for future identification and search is now commenced for the vesical end of the urethra. This may be found as a loose shred of tissue, or it may resemble the twisted end of a large blood-vessel. Sometimes the urethra is found by the persistent bleeding of a small vessel in its wall. Every depression should be carefully probed under a strong light. Should a careful search fail to reveal the stump of the urethra the gloved forefinger of the left hand may be introduced into the rectum, and when placed at the apex of the prostate will indicate the exact position of the membranous urethra; by probing at this spot the opening may be found. Lastly, pressure above the pubes by an assistant will cause some urine to trickle from the over-distended bladder and betray the position of the vesical stump of the urethra.

If the search be successful, the urethra is picked up in fine forceps and approximated to the penile stump. A gum-elastic catheter is passed along the penile urethra and projects into the wound. It is now manipulated into the vesical stump of the urethra and pushed on into the

bladder, without, however, allowing more than a few drops of urine to escape. The torn ends of the urethra are now drawn together and united with catgut sutures.

The cavity is lightly packed with strips of iodoform gauze and a drainage tube introduced down to the urethra. The perineal muscles and the skin are brought together, leaving ample room for the tube and gauze. The gum-elastic catheter in the urethra is fixed in position by tying a piece of silk or narrow tape round it and bringing the ends along the sides of the penis, and fixing them there by a strip of adhesive plaster longitudinally placed on each side.

Suprapubic drainage of the bladder should now be established. If the bladder be not already distended with urine, 12 or 14 ounces of warm boric lotion are introduced through the catheter by means of a syringe. The steps of the operation will be found on p. 430.

A $\frac{1}{2}$-inch diameter rubber drainage tube is introduced into the suprapubic opening and the urine is drained away by an apparatus. The suprapubic drainage is continued for a fortnight. The catheter is retained for four days and then removed, and the perineal drain is replaced by a strip of gauze at the same time.

Should the search for the vesical end of the urethra prove fruitless, a suprapubic cystotomy should be performed and a bougie inserted into the vesical end of the prostatic urethra and made to project in the perineal wound. The vesical stump of the urethra is easily found and a catheter guided from the penile portion into this and passed into the bladder. The operation is now completed as before.

Should the urethral wall be so extensively destroyed that the ends of the tube cannot be approximated, they should be stitched to the soft tissues or skin of the perineum, so that at a later date, when a plastic operation is performed to close the fistula, the ends of the urethra may be easily identified.

After the healing of an injury to the urethra, whether slight or severe, instruments should be passed in order to make certain that contraction of the urethral scar has not taken place, and if a narrowing of the canal is found the regular passage of instruments should be arranged or excision of the structure may be performed. If there be no sign of stricture the patient should return for examination at intervals.

Some discussion of the following points is necessary :—

1. *The perineal incision and search for the urethra.* When the rupture of the urethra is far back, and especially if it be in the membranous urethra, a transverse prerectal incision will give a better exposure. It has been advocated by Bazy, Legueu, Riche, and Roux.[1]

[1] *Annales des maladies des organes génito-urinaires*, 1904, vol. xxii, p. 187.

2. *Suture of the urethra.* Suture of the urethra frequently fails to bring about immediate union of the torn ends of the urethra and some surgeons are opposed to the use of sutures. Rutherfurd,[1] with considerable experience in the treatment of ruptured urethra, opposed the use of sutures on the ground that they were an 'unnecessary complication of the healing'.

The use of silk or other suture material, which is not readily absorbed and may act as an irritant, is no doubt objectionable, but fine catgut does not possess these disadvantages, and the use of some means of approximation of the torn ends of the urethra has such obvious advantages that the writer strongly recommends it.

3. *The bladder drainage.* Some authorities advise suprapubic puncture of the bladder for the initial retention of urine, followed by repeated aspiration of the bladder several times in the twenty-four hours for several days to prevent the urine passing along the urethra and soiling the wound. Neither this procedure nor the voluntary efforts of the patient to retain the urine can, however, be relied upon. The passage of some urine along the urethra is almost certain to take place and extravasation of urine or perineal abscess is the result.

The method of suprapubic drainage and immediate suture of the urethra was recommended by Gilbert Barling[2] in 1891. Rutherfurd[3] independently developed a somewhat similar procedure in 1898. He tied a soft rubber catheter in the urethra and drained the bladder by suprapubic cystotomy. The urethra was left unsutured.

Mortality. (*a*) Uncomplicated rupture of the urethra.

Kaufmann[4] collected from the literature 205 cases of injury to the urethra, 29 of which died, a mortality of 14·15%. The complication of urinary infiltration seriously affected the mortality figures and produced a death-rate of almost 36% in the cases in which it occurred. Treatment by retained catheter produced a mortality of 18·17%. When it is remembered that the latter were the cases in which the damage was least extensive this mortality is very high.

In 91 cases where perineal section was made within the first two days after the injury 8 died, a mortality of 8·79%. Of 24 cases in which perineal section was made after several days (eight to ten days) 8 died, a mortality of 20%.

(*b*) Rupture of the urethra with fracture of the pelvis.

Of 48 cases in the Kaufmann collection 20 died (40%). Oberst[5]

[1] *Lancet*, September 10, 1904.

[2] *Birmingham Medical Review*, 1891, vol. ii, p. 321.

[3] *Glasgow Hospital Reports*, 1898, vol. i.

[4] *Loc. cit.*

[5] *Volkmann's Sammlung. Klinische Vorträge*, No. 210.

found that in 16 cases submitted to perineal incision 4 died (25 %), in 12 cases where a catheter was retained 5 died (42 %), and in 8 cases where suprapubic puncture was practised 3 died (37 %).

Martens[1] collected 17 cases of ruptured urethra, in 4 of which there was also fractured pelvis. One patient died, a mortality of 5·7 %. All these cases were submitted to perineal section and immediate suture of the urethra.

(*c*) Gunshot wounds of the urethra.

In 119 cases Kaufmann found a mortality of 22 %. In the 26 fatal cases death was due to hæmorrhage in 3, extravasation of urine in 8, septic inflammation and pyæmia in 14, and scurvy in 1.

Functional results. In the American War of the Rebellion[2] the after-result of 74 cases that survived gunshot wounds of the urethra was as follows: complete healing 10, stricture 26, fistula 38.

The formation of a stricture after rupture of the urethra was an almost invariable result in the cases recorded by the older writers. This result was apparently due to sloughing and septic inflammation.

Where primary union or rapid healing of the urethra is obtained, the canal either remains uncontracted or the stricture which forms is a simple narrow ring, readily amenable to treatment, instead of a tortuous cartilaginous stricture.

In 7 cases operated on by Rutherfurd,[3] the urethra was free from stricture in 5 at periods of sixteen months, seventeen months, three years, three years, and six years respectively after the injury. Two cases developed stricture, which was resected, and no recurrence of the stricture had taken place eighteen months and seven years respectively after the injury.

Cabot[4] records 5 cases of rupture of the urethra treated by immediate suture. No stricture was present from three to five years after the injury in these cases.

[1] *Die Verletzungen und Verengerungen der Harnröhre*, Berlin, 1902.

[2] *The Medical and Surgical History of the War of the Rebellion*, Washington, 1877, vol. ii, Part II, p. 350.

[3] *Loc. cit.*

[4] *Boston Medical and Surgical Journal*, July 16, 1896, p. 57.

CHAPTER XIX

OPERATIONS FOR STRICTURE OF THE URETHRA

THE majority of cases of stricture are cured or relieved by the passage of instruments, but in a certain number of cases a cutting operation becomes necessary.

The recorded opinions of different surgeons vary widely in regard to the necessity for operative interference in uncomplicated stricture of the urethra. While some surgeons, such as Albarran,[1] Goldberg,[2] and Heresco,[3] look upon the operation as one which should be practised, in the great majority of cases. as a preparation or as an aid to the passage of sounds, others—Burckhardt[4] among the number—look upon the incision of a stricture as an operation which is seldom necessary. In Burckhardt's experience 89·8% of all stricture cases are cured by simple dilatation.

Indications. The indications for a cutting operation for stricture are many and varied.

A. Gradual dilatation may have been tried and proved inadequate or unsuitable.

(1) In cases of hard cartilaginous stricture dilatation may be carried up to a certain size and no further progress be made. Urethrotomy is performed and the passage of instruments resumed.

(2) A stricture may be readily dilated, but very quickly relapses to its former size (resilient stricture).

(3) With careful antiseptic precautions and with the most gentle manipulation, rigors may follow each passage of an instrument.

(4) A few strictures bleed at the slightest touch of a bougie. These cases are few, and are not to be confounded with the more frequent hæmorrhages which result from lack of skill or want of care on the part of the operator.

(5) Repeated attacks of epididymitis sometimes interrupt the progress of intermittent dilatation, and, if the stricture be freely cut, relief from these may be obtained.

[1] *Comptes Rendus XIII^e Congrès Internat. de Méd.*, 1900.

[2] *Deutsche Zeitschr. f. Chir.*, vol. lvii, Nos. 5 and 6.

[3] *Comptes Rendus XIIIe Congrès Internat. de Méd.*, 1900.

[4] Frisch und Zuckerkandl, *Handb. d. Urologie*, 1906, vol. iii.

(6) When recurrent attacks of retention of urine follow the passage of instruments in a stricture of moderately large calibre.

(7) Peri-urethral abscess and extravasation of urine may complicate stricture during the course of intermittent dilatation and necessitate immediate operation.

B. The case may be considered unsuitable for gradual dilatation.

(1) The stricture may be impassable to the finest bougie. In experienced hands these cases are very few in number; but a cutting operation is equally indicated when the stricture on several successive visits will only admit a fine bougie after much difficulty.

(2) In cases of urethral stone, peri-urethral abscess, extravasation of urine, and urethral fistula, operative interference is necessary.

(3) The stricture may be a complication of some disease of the prostate or bladder, such as enlargement of the prostate, stone, tuberculosis, or new growths, and incision of the stricture is the most rapid preparation for a complete examination. Chronic cystitis complicating stricture may be an indication for urethrotomy.

(4) In some diseases of the kidneys complicating stricture of the urethra the most rapid method of completely removing the obstruction is that which is safest.

C. The stricture may be suitable for gradual dilatation, but the patient is unable or unwilling to carry out the treatment.

(1) He may be going abroad beyond reach of medical aid.

(2) He may prefer the cutting operation on account of the longer time required for gradual dilatation.

INTERNAL URETHROTOMY

This operation consists in cutting through the stricture by means of a guarded knife (urethrotome) introduced along the urethra. The stricture may be cut from before backwards—that is, towards the bladder—or from behind forwards; and it may be cut on the roof of the urethra or on the floor.

INTERNAL URETHROTOMY FROM BEFORE BACKWARDS

There are many urethrotomes which cut from before backwards. The principle which underlies these instruments is that a very fine staff is passed through the stricture and acts as a guide along which the guarded knife which is to cut the stricture is pushed.

Maisonneuve's urethrotome (see Fig. 305) consists of a fine curved staff (No. 8 F.) which has a deep groove on the concave surface from the distal to the proximal end. At the point of the staff is a male screw on to which a small bulbous tip screws. This tip may be removed and

a fine flexible guide (No. 4 F.) screwed on to the end of the staff by means of a metal end with a female screw. A triangular knife is fixed at one end of a fine steel rod, the other end of which is button-like. The apex of the triangular knife is blunt, smooth, and broad, so that it can glide along the mucous membrane without cutting it. The anterior and posterior edges of the triangle are sharp. A small ring is attached to the shaft near the end, so that it may be steadied by the finger and thumb of an assistant.

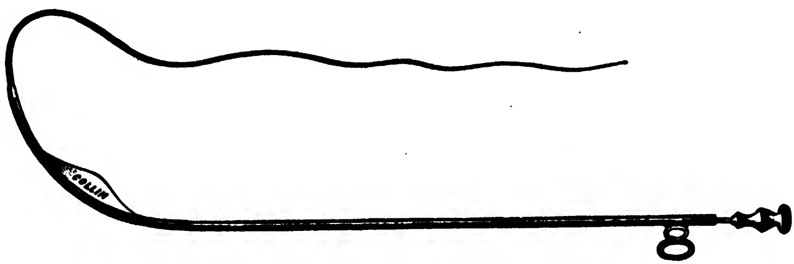


FIG. 305. MAISONNEUVE'S URETHROTOME.

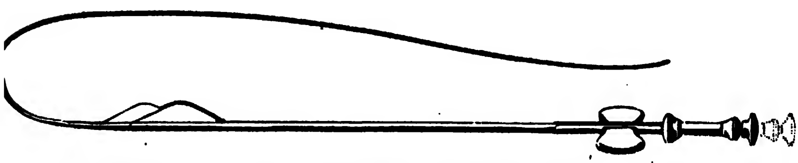


FIG 306 TEEVAN'S URETHROTOME.

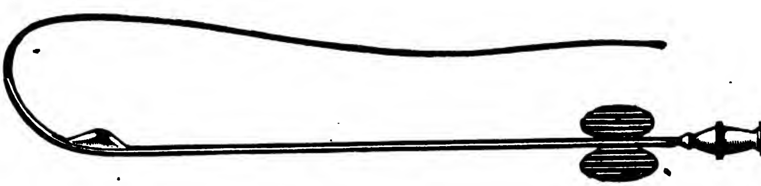


FIG. 307. AUTHOR'S URETHROTOME.

Teevan's modification of this instrument (see Fig. 306) has a thicker staff, and inside the deep groove in this is a second groove. The knife-carrying shaft consists of a triangular sheath attached to a fine tube. Inside this lies the triangular knife and the rod which carries it. The knife is held in place by a spring, and is projected from the sheath by pressing the button end of the knife-carrying shaft, and recoils within the sheath again when pressure is removed. The knife and sheath fit into the grooves in the staff. A cross-piece serves to steady the staff when in position.

Author's urethrotome (see Fig. 307). Without interfering with the

simplicity of Maisonneuve's instrument, I have modified it in certain particulars, and the following urethrotome is, I believe, a more serviceable instrument. The filiform guides supplied with Maisonneuve's urethrotome are connected with a bulbous metal tip containing the female screw. This gives an abrupt shoulder which may hitch in a narrow stricture, and, further, the guide is liable to become frayed at this point, and has even broken across and been left in the bladder. In the guides supplied with my instrument the metal junction into which the male screw fits is tapered, and passes for a short distance inside the flexible guide, which thus expands gradually to the thickness of the staff, and there is no abrupt union of flexible bougie and rigid metal. Maisonneuve's instrument has a very wide curve which is different from the curve of the urethra, and the groove for the knife runs as far as the end of the staff. The result is that the instrument fits the urethra badly and that the knife passes into the prostatic urethra when it is pushed to the hilt. In the new instrument the curve is that given to well-made steel bougies and corresponds to the curve of the urethra. The groove passes just beyond the beginning of the curve, so that, when the staff is held in the proper position, the knife will not pass further than the entrance of the membranous urethra. Two large flat transverse wings replace the single vertical ring and provide a good grip for the thumbs and fingers of an assistant. A steel rod fits into the groove in the staff and serves to stiffen it during the introduction of the instrument, and is useful for cleaning it. The rod is removed for the insertion of the knife.

Operation. A general anæsthetic is preferable, but where this is contra-indicated the instillation of twenty minims of a 2% solution of cocaine or a solution of eucaine and adrenalin will suffice, or spinal analgesia may be used. The penis is cleansed and drawn through a small hole in a sheet of sterile lint. The urethra is washed out with a weak antiseptic solution, such as biniodide of mercury (1 in 10,000) or oxycyanide of mercury (1 in 10,000), supplied from a douche can and glass nozzle. The guide should now be introduced, and care is taken that it passes through the stricture and does not double up in front of it. If the stricture be sufficiently large to admit a No. 8 French bougie, the filiform guide may be dispensed with, the small bulbous end screwed on the tip of the staff, and the instrument passed through the stricture.

The surgeon stands on the right side of the patient. In a narrow stricture the fine staff is screwed on to the guide, and the instrument, well oiled, is pushed onwards, taking care that the guide does not double up in front of the stricture. The staff passes through the stricture and lies with the curve in the membranous and prostatic segments of the urethra, the flexible guide coiling inside the bladder.

The staff is held by an assistant at an angle of 45° with the horizontal. He grasps the wings of the urethrotome with a thumb on the upper surface of each and holds the instrument absolutely steady in the middle line.

FIG. 308. INTERNAL URETHROTOMY. Staff held in position by the assistant. The surgeon's hand is pushing the blade through the stricture.

The surgeon dips the point of the triangular knife in sterile oil and introduces it into the groove of the staff. Raising the glans penis with the left thumb and fingers, the knife is slipped past the meatus, and holding the button at the end of the knife rod, is pushed steadily along the urethra until the resistance of the stricture is felt. A sharp push cuts the stricture, and

the knife slips on and cuts any other strictures that may be present and is finally arrested at the end of the groove (see Fig. 308). The knife is now steadily withdrawn, and when it reaches the stricture on its way out resistance is again felt, and a tug at the rod cuts this through with the sharp reverse edge of the knife. Unless the knife be boldly pushed through the stricture, the fibrous tissue will not be properly cut. The knife rod is withdrawn altogether and the staff and guide then removed.

If Teevan's instrument be used, the procedure is similar until the knife guard is arrested by the stricture. The knife is now projected by pressing the button end and the stricture is cut. On releasing the button the knife springs back under cover of the guard. The knife guard is now pushed onwards through the cut stricture to the next, and when all are cut, the whole instrument may be withdrawn without removing the knife and its guard.

The next step consists in the passage of large steel bougies in order to make certain that the stricture has been cut to the full size. A steel sound of $\frac{12}{14}$ size is passed, and followed by $\frac{13}{15}$ and $\frac{14}{16}$. There is no question here of dilating the cut stricture. If the fibrous ring be not sufficiently cut, resistance to the passage of the instruments will be felt and the urethrotome should again be passed, this time with the bulbous end in place of the filiform bougie, and the knife again run through the stricture. If the meatus be too narrow to admit a large steel instrument, it should be slit downwards by means of a blunt-pointed bistoury introduced into the urethra. Having passed a large steel sound, a coudé catheter (No. 22 F.) is passed into the bladder, and the urine drawn off. If the urine be foul, the bladder should be washed with a weak solution of biniodide or oxycyanide of mercury by means of a large bladder syringe, or a solution of nitrate of silver (1 in 10,000) may be used. The catheter is withdrawn until the eye lies just within the bladder, and tied in. A roll of aseptic gauze is placed around the catheter at the external meatus and is held in position by the tapes that secure the catheter. A syringeful of fluid is injected to ascertain that the catheter eye is in the bladder, a plug is inserted into the end of the catheter, and the patient returned to bed.

After-treatment. The urine is drawn off at frequent intervals by removing the plug from the catheter, or a piece of rubber tubing may be attached and the bladder drained continuously into a urinal. If the bladder be allowed to become distended, the urine may be forced alongside the catheter and come in contact with the urethral wound and the object of the retained catheter is defeated. At the end of forty-eight hours the catheter is removed and the urethra may be washed with an antiseptic lotion. The patient now passes water himself.

If the catheter does not drain efficiently, it is usually due to the instrument having slipped out so that the eye is in the prostatic urethra, or to a clot obstructing the lumen. Pushing the catheter in a little way or the introduction of a syringeful of lotion will re-establish the flow.

INTERNAL URETHROTOMY FROM BEHIND FORWARDS

In this operation an instrument carrying a small knife is passed through the stricture. The knife is then elevated so that it forms an angle with the shaft of the instrument and drawn out, cutting through the stricture. Thompson's modification of Civiale's original instrument (see Fig. 309)

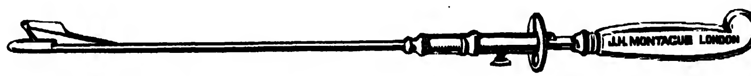


FIG. 309. CIVIALE'S URETHROTOME MODIFIED BY THOMPSON.

consists of a handle, a shaft, and a sheath containing a fine blade. The sheath is wedge-shaped, and flattened at the sides. The calibre corresponds to a No. 5 instrument of the English scale. At the junction of the shaft and handle is a hilt, and about 1 inch from this on the shaft is a small button. While holding the handle in the grasp of the right hand with the thumb pressed against the hilt, the forefinger may be pressed upon the button and the hilt pushed towards it. This draws and elevates a fine blade out of the sheath, and on releasing the hilt the knife again returns to its sheath.

Operation. Before using this instrument the stricture must be dilated to the size of a No. 5 English bougie. The instrument is introduced vertically into the urethra until it has passed through the stricture. It is now withdrawn, still held vertically, until the knife-guard hitches against the back of the stricture. The knife is now elevated in the manner already described and drawn through the stricture with a sharp tug. It is then returned to the sheath, and the remaining steps of the operation and the subsequent treatment carried out in the same manner as after urethrotomy from before backwards.

There are several questions connected with the operation of internal urethrotomy which have given rise to controversy.

Dilatation during and immediately after the incision of the stricture. There are some forms of urethrotome, and that of Otis may be specially mentioned, in which the operation is a combination of cutting and 'bursting' of the stricture. An instrument with two or more blades is passed through the stricture. These blades are separated by a special mechanism, and with the stricture fully on the stretch it is cut with the knife between the separated blades.

Instead of using such an instrument, which necessitates a previous dilatation of the stricture, the stricture may be cut by means of a urethrotome and then dilated by the forcible passage of large bougies. The wound which results from this cutting and tearing operation is ragged and irregular. It is accepted by most modern surgeons that rapid dilatation, or 'bursting' a stricture by the forcible passage of bougies of increasing size rapidly introduced in succession, is likely to give rise to tearing of the submucous tissues and the eventual formation of an irregular and dense scar. The methods just described are a modification of this procedure.

In performing internal urethrotomy the stricture should be freely and cleanly cut, and the passage of a steel instrument afterwards should have the sole object in view of ascertaining whether the stricture is completely severed or whether some uncut strands still remain.

Cutting from before backwards or from behind forwards. So far as safety is concerned no preference can be given to one method over the other. Maisonneuve's blade, which might be looked upon as the more dangerous of the two urethrotomes above described for antero-posterior urethrotomy, pushes up the mucous membrane with the flat apex of the knife as it glides along the staff, and, so long as the mucous membrane is supple and healthy, it is lifted clear of the cutting portion of the blade. Whatever is rigid and tough is not raised up and is cut through. With the guiding staff firmly held at the proper angle there is no danger of cutting too deeply, and with the writer's modification the blade will not enter the membranous urethra.

It is an undoubted disadvantage that the calibre of the stricture must be the size of a No. 5 English bougie before Civiale's instrument can be used for postero-anterior urethrotomy. There is nothing to choose between the two methods in regard to the thoroughness with which the stricture can be cut.

Cutting on the roof or the floor of the urethra. Civiale's instrument cuts the stricture on the floor; the form of Maisonneuve's urethrotome most frequently used cuts on the roof, but it may also be made with the groove so placed that the stricture is cut on the floor. The object of the operation is to cut the fibrous obstruction at its most extensive part. It is stated by some writers that this is always to be found on the floor. Urethroscopic experience does not uphold this view, and in strictures which have so far contracted as to necessitate urethrotomy the greatest development of fibrous tissue is as frequently to be found on the sides or roof of the urethra as on the floor. In the majority of cases which are submitted to internal urethrotomy the fibrous contraction affects the whole circumference of the urethra, and although the lumen is seldom to be found exactly in the centre, there is a considerable depth of fibrous tissue sur-

rounding it on all sides, so that an incision radiating from the lumen to any point in the circumference will sever the ring.

The process of repair of the urethra after incision does not, however, necessitate the selection of the segment in which the greatest amount of fibrous tissue has developed. It is only essential, in the view of the writer, that the circular tension of the ring of fibrous tissue should be abolished, and that the stream of urine, instead of being projected against the back of a tense ring of fibrous tissue with a narrow rigid opening, should flow through a wide opening which has merely loose flaps of tissue at the position of the stricture.

Burckhardt [1] gives the following reasons for insisting that the incision must invariably be placed on the roof: In the bulbous urethra there is less erectile tissue, and the blood-vessels are fewer on the roof than on the floor; the danger of hæmorrhage is therefore less. The mucous membrane of the roof is more fixed and steadier, so that the incision is more accurate. There is less fear of urinary infiltration in a wound of the roof than in one in the floor. Where, however, the stricture is subpubic, the floor is safer than the roof on account of the proximity of the venous prostatic plexus to the latter.

Draining the bladder by a retained catheter after the operation. The catheter must be one or two sizes smaller than that to which the stricture has been cut, for it should not put the stricture wound on the stretch. At the same time a small calibre catheter is to be avoided, for the urine will easily trickle alongside a catheter which lies loosely in the urethra, and there is much greater danger of the lumen of the instrument becoming blocked with a small clot. A No. 20 or 22 French catheter is suitable for most cases, and the eye should be near the end of the instrument. The object of the retained catheter is not to keep the edges of the wound apart and prevent recontraction, as some surgeons seem to suggest.[2] This is sufficiently provided for by the passage of instruments at a later date. By means of the catheter the urine, which is frequently septic and is always poisonous, is prevented from coming in contact with the raw surface of the wound. In the experience of the writer there is less frequently a rise of temperature during the first twenty-four hours after the operation when a catheter is retained than when it is dispensed with. It sometimes happens, as if to demonstrate the efficacy of the catheter, that immediately after the first micturition following its withdrawal the patient has a slight rigor and the temperature shoots up to 101° or 102° and falls again in a few hours.

[1] Frisch und Zuckerkandl, *Handbuch d. Urologie,* 1906, vol. iii.

[2] Heresco, *Comptes Rendus XIII^e Congrès Internat. de Méd.,* 1900.

The presence of the catheter in the urethra affords a ready means of washing the bladder, which should be taken advantage of when the urine is septic.

Spasm of the bladder sometimes occurs after the operation, and may be due to the use of too strong antiseptic solutions in washing the bladder at the time of the operation, or to the end of the catheter projecting too far into the bladder and continually pressing on its wall. In the great majority of cases a properly placed catheter is borne without discomfort and is efficient in preventing contact of the urine with the wound. A few nervous individuals find the presence of the catheter intolerable, and it is soon dislodged by their constant efforts, so that the urine enters the urethra alongside the instrument. If this occurs, the catheter should at once be removed.

After-treatment. After removal of the catheter the patient is kept quiet in bed for a week and then allowed up. A daily irrigation of the urethra may be given if there be any urethritis, or if the urine be foul, but this is unnecessary if the urine is clear. No instruments are passed for fourteen days after the operation, and then a full-sized steel sound is introduced and usually passes without difficulty. After the first passage of instruments the patient returns in a fortnight for a second, and if the surgeon be satisfied that no recontraction is taking place, the next visit should be paid a month later, then two, three, and six months, and eventually the patient returns at the end of a year's interval, when, if no obstruction to the passage of a large steel instrument is detected, he may be dismissed as cured. Should recontraction of the stricture take place, instruments must be regularly passed at proper intervals.

Difficulties and dangers. 1. *The fine guide of the urethrotome may break* across at the junction with the metal base which unites it to the staff and on withdrawing the instrument it is left in the bladder. If this accident occurs, a small lithotrite should at once be passed and the guide grasped between its jaws and removed.

2. *After the removal of the urethrotome the surgeon may fail to pass a metal sound.* The difficulty is sometimes due to imperfect cutting of the stricture by a blunt knife or to a want of boldness in the cutting stroke. Sometimes an elastic stricture stretches before the pressure of the knife-sheath of Teevan's instrument and thus escapes incision.

The guide of the urethrotome should be replaced by the small metal bulbous tip, the staff reintroduced, and the structure cut to the full size. Should the surgeon fail to introduce the urethrotome staff, a moderate-sized gum-elastic bougie (No. 12 F.) is the instrument most

likely to pass. A Harrison whip-bougie is a useful instrument in this dilemma.

3. *Hæmorrhage.* There is rarely any serious bleeding following internal urethrotomy. At the time of the operation the bleeding is inconsiderable, and for the first two days the urine withdrawn by the retained catheter may be blood-stained. Serious hæmorrhage has, however, occasionally taken place, and a few fatal cases have been recorded. With the more accurate modern urethrotomes such an accident very rarely occurs. No fatal cases occurred among the large number operated upon at St. Peter's Hospital.

When bleeding takes place after internal urethrotomy the foot of the bed should be raised, an icebag containing finely-crushed ice should be placed upon the perineum, and firm pressure applied by means of a large sand-bag. Sand-bags or other support should be arranged so as to prevent the shoulders of the patient slipping towards the head of the bed. If a catheter be in the urethra it should be allowed to remain *in situ*, as it will assist the pressure and allow of the escape of the urine. Without it, bleeding, which has been stanched, tends to recommence on micturition. A hypodermic injection of ergot and opium should be given.

Should these measures fail, the catheter should be removed and the urethra irrigated with hot solution of silver nitrate (1 in 10,000) or a solution containing tincture of hamamelis or adrenalin, and pressure reapplied. If spasm appears to be a factor in the causation of the hæmorrhage, hot fomentations may be tried.

Finally, should the hæmorrhage resist all treatment, a perineal section should be rapidly performed and a large rigid tube introduced into the bladder; around this iodoform gauze should be firmly packed.

Results. 1. *Mortality.* The operation of internal urethrotomy carries with it a remarkably small mortality. In most of the cases where death has followed the operation it has resulted from an exacerbation of pre-existing disease occasioned by the operation and not from any new factor introduced by the operation itself.

I have examined the records of this operation performed at St. Peter's Hospital during a period of thirteen years (1895–1908). In all, 1,316 patients suffering from stricture of the urethra were submitted to operation in the wards of the hospital.[1] The operation of internal urethrotomy alone was performed in 1,018 of these cases. Eight patients died after the operation, giving a mortality of 0·78%.

[1] This does not include patients treated in the out-patient department of the hospital. I have calculated that 27% of cases of stricture are submitted to operation, and the 1,316 cases will represent this proportion of the total.

The following statistics are to be found in the literature :—

	Number of cases.	*Deaths.*	*Percentage mortality.*
Guyon[1] (1880–90)	1,000	5	0·5
Guyon[2] (1890–1900) . . .	980	11	1
Thompson[3]	340	6	2
Lydston[4]	1,500	0	0
Nicolich[5]	235	1	0·4
Desnos[6]	78	0	0
Pousson[7]	500	0	0
Schliffka[8]	16	0	0
Goldberg[9]	7	0	0

Watson and Cunningham[10] have collected the published results of a number of surgeons, some of which are included in the above list. In a total of 4,686 operations there were 53 deaths, a mortality of 1·1 %.

Death may follow internal urethrotomy in several ways :—

(*a*) In many cases of long-standing stricture there is chronic cystitis together with chronic septic pyelonephritis. The operation is followed by an acute exacerbation of pyelonephritis, which is fatal. This was the cause of death in four out of the eight fatal cases (50 %).

(*b*) Chronic interstitial nephritis complicates prolonged urinary obstruction, and death from renal failure may follow internal urethrotomy performed for the relief of the obstruction (one case).[11]

(*c*) Complete anuria and death from urinary or septic intoxication may occur within a few hours or days of the operation (two cases).

(*d*) Septicæmia or pyæmia may follow the operation without interference with the secretion of urine (one case).

(*e*) A few cases of death from hæmorrhage have been recorded, after operation with the older forms of urethrotome, where the prostatic plexus of veins was injured.[12]

2. *Healing of the stricture after internal urethrotomy.* The results obtained after internal urethrotomy vary with the character of the stricture. In a well-defined annular stricture in a healthy subject, internal urethrotomy may result in a complete cure. In the practice

[1] Desnos, *Annales des maladies des organes génito-urinaires*, 1891, p. 21.

[2] Noguès, *Notice sur l'organisation et le fonctionnement de la clin. d. v. urinaires*, Paris, 1900.

[3] *Stricture of the Urethra*, 1885.

[4] *Med. News*, March 4, 1899.

[5] *Wien. med. Presse*, 1899, 50.

[6] Noguès, *loc. cit.*

[7] *Annales des malad. d. org. génito-urin.*, 1891, p. 206.

[8] *Wien. med. Presse*, 1898, vol. xlvi.

[9] *Deut. Zeitschr. f. Chir.*, 1900, vol. lvii, p. 393.

[10] *Diseases and Surgery of the Genito-urinary System*, 1909.

[11] Thomson Walker, *The Renal Function in Urinary Surgery*. Cassell & Co., 1908.

[12] Thompson, *Stricture of the Urethra*, 1888 (one case); Fenwick, *Illustrated Medical News*, 1888, No. 3 (two cases).

of the writer this has occurred in a number of cases and the urethra, examined as long as two and three years after the internal urethrotomy, showed no sign of stricture or of the scar of the operation.

In a second group of cases there is a recontraction of the stricture after a period varying from a few months to several years, but the occasional passage of a large metal sound at intervals of several months is sufficient to prevent further contraction.

There is a third group of cases, and this forms a very large proportion of the hospital class of patients, where internal urethrotomy permits of the passage of large instruments at intervals, without which the stricture would rapidly recontract. Irregular attendance, alcoholic indulgence, and other causes frequently produce relapses, so that the cutting operation may have to be repeated and the dilatation resumed. These cases merge into the next class.

The final group is that of cartilaginous stricture, where there is no prospect of cure by urethrotomy or dilatation. This group forms a small proportion of cases treated, and most of them belong to the hospital class of patients. Urethrotomy is performed to enable a good-sized instrument to be passed, and it may be possible by intermittent dilatation to maintain the lumen at this calibre or even with care to increase it. Frequently, however, the stricture slowly recontracts in spite of instrumentation and internal urethrotomy must be repeated and dilatation recommenced.

Internal urethrotomy alone cannot be looked upon as a radical operation for the cure of stricture. Although a certain proportion of cases are cured by this means alone, yet in the majority of cases the passage of instruments must be added to complete the cure or to prevent relapse, and in a small percentage even this combination is insufficient to prevent recontraction of the stricture.

In 100 cases of stricture attending my out-patient department at St. Peter's Hospital 17 had undergone internal urethrotomy. Of these 12 had been operated on once with the following results :—

Time since operation.	*Size of instrument.*	*Attendance.*
A few months	14/16 steel	Regular
A few months	14/16 steel	Regular
One year	13/15 steel	Regular
One year	12/14 steel	Regular
One year	15 F. bougie	Irregular
Two years	12/14 steel	Regular
Three years	13/15 steel	Regular
Three years	12 F. bougie	Irregular
Four years	14/16 steel	Regular
Eleven years	12 F. bougie	Irregular
Fifteen years	10/12 steel	Regular

Five cases required more than one operation.

Number of operations.	*Treatment between operations.*	*Present size.*
Two	Regular dilatation, seventeen years	14 F. bougie
Two	Neglected after first operation	12/14 steel
Five	Irregular dilatation	18 F.
Two	External then internal urethrotomy, neglected	14/16 steel
Two	External then internal urethrotomy	11/13 steel

From these figures it will be seen that a stricture which has been submitted to internal urethrotomy usually contracts again if it is not dilated regularly. If regular dilatation be undertaken the calibre of the stricture remains large.

In a few cases, in spite of regular passage of instruments, the stricture recontracts and another operation is required, after which regular dilatation may keep the stricture fully dilated.

EXTERNAL URETHROTOMY

The operation of external urethrotomy consists in cutting a stricture by an incision made through the perineum. There are many variations of this procedure and the names of various surgeons have been connected with these.

Choice of method. The principal dividing line in the varieties of external operation upon stricture is the possibility or impossibility of passing an instrument through the stricture before the operation. If an instrument can be passed through the stricture and it is determined to perform external urethrotomy, the operation may be carried out by passing a Syme's staff and cutting the stricture upon this, and the operation is called Syme's operation; or an ordinary grooved staff may pass through the stricture with or without previous dilatation and the incision be made on this; or a staff designed by Morris may be used; or, finally, a filiform guide may be passed and the urethra opened in front of the stricture on this and the stricture divided upon it. If an instrument cannot be passed through the stricture the urethra may be opened upon a straight staff in front of the constriction and a search made for the lumen of the stricture, and when this is found and a probe passed through it, the stricture is cut from before backwards upon this (Wheelhouse's operation). If the lumen cannot be found the urethra may be approached from behind the stricture by a median perineal incision, using the point of the left forefinger placed in the rectum at the apex of the prostate as a guide (Cock's operation), or the urethra may be exposed behind the stricture by dissection from the perineum and incised, or suprapubic cystotomy may be performed and a sound passed along the urethra from the bladder may be cut upon from the perineum. The stricture may or may not be

cut through in this operation. If it be, then a probe or a director should be passed behind forwards and the stricture cut upon this. Finally, the methods of after-treatment vary. A catheter may be introduced along the whole length of the urethra and retained; the urethral wound may be left alone or it may be stitched; or a tube may be placed in the bladder through the perineal wound, or no drainage, either urethral or perineal, may be adopted.

Such are the more important variations of the operation of external urethrotomy. The term perineal section will here be avoided since some confusion has arisen as to its exact application.

EXTERNAL URETHROTOMY WITH A GUIDE

Syme's operation.[1] The operation consists in the passage of a Syme's staff through the stricture and cutting upon this immediately in front of the obstruction, and then cutting through the stricture.

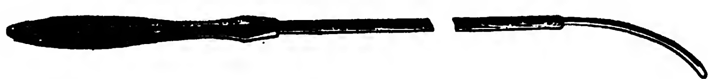


FIG. 310. SYME'S STAFF.

Syme's staff (see Fig. 310) has a straight shaft and a curved terminal portion. The shaft is equal in gauge to a No. 12 English sound; it terminates abruptly in a shoulder, and the curved terminal portion is equal in size to a No. 4 English sound. A deep groove commences on the shaft about ½ inch behind the shoulder and passes on to the convexity of the fine terminal portion almost to the point of the instrument.

Operation. The operation is performed as follows: The stricture is dilated to the size of a No. 4 English gauge by means of bougies, either by continuous dilatation by tying in a filiform bougie overnight and changing it to a larger instrument, or by the rapid passage of bougies of increasing size. The perineum is shaved and prepared. The patient is anæsthetized and the Syme's staff is passed along the urethra until the shoulder is arrested by contact with the stricture. External urethrotomy is sometimes performed when the stricture is of sufficient calibre to pass a No. 12 English or larger sound. In this case there is no object in using a Syme's staff, and a curved staff with median groove is introduced instead. The patient is now placed in the lithotomy position by means of a crutch or by supports, and an assistant standing at the level of the pelvis on the left side holds the staff vertically exactly in the middle line, grasping the instrument firmly with the right hand, the

[1] *Edinburgh Journal of Medical Science*, October, 1844.

thumb erect on the upper face of the handle. With his left hand he supports the scrotum vertically. The staff can be felt from the perineum, and an incision is made directly upon it just behind the shoulder, cutting through all the tissues right down to the staff. The urethra may remain undivided in the first incision and the finger can feel the groove in the shaft just behind the shoulder. The point of the knife enters this and is carried along the groove, cutting the stricture in the middle line. The urethra should be cut as far back as the commencement of the membranous portion, and upon this will depend the ease with which the subsequent steps of the operation are performed. In bringing the knife out care should be taken to divide the skin and perineal tissues somewhat more freely than the urethral wall.

The point of a probe-pointed gorget (see Fig. 311) is now introduced into the groove in the staff and pushed onwards into the bladder. The staff is then withdrawn. If the surgeon decides to drain the bladder by means of a catheter, a No. 22 F. silk-wove coudé catheter is introduced along the penile urethra and projects into the wound. It is easily directed along the gorget into the bladder and is retained in place by two strips of tape knotted around it, and the ends brought along the penis and fixed to it by means of adhesive plaster. The perineal wound is either left open and a dressing applied, or one or two catgut stitches are placed in the urethral wall and corpus spongiosum, and the rest of the wound left open. The catheter may be changed or left out entirely at the end of three or four days. Instead of tying a catheter in the urethra a large perineal drainage tube may be introduced into the bladder with the help of the gorget. The best form of tube for this purpose is a large-sized rubber tube with smooth rounded end and terminal and lateral openings (see Fig. 312). The tube is guided along the grooved surface of the gorget, which is gradually withdrawn and the tube pushed on through the vesical sphincter. A gush of urine shows that it has reached the bladder. The end of the tube should not project too far into the bladder. The proper position is ascertained by withdrawing it a little and injecting a syringeful of warm boric lotion and watching its return through the tube, and by this means making certain that the eye of the tube lies just within the sphincter of the bladder. A movable metal ring

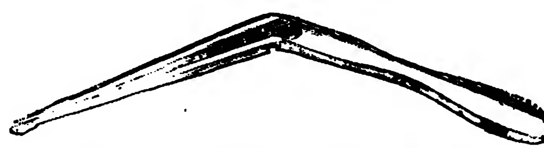


FIG. 311. PROBE-POINTED GORGET.

FIG. 312. PERINEAL DRAINAGE TUBE.

provided with a loop on each side surrounds the tube, and tapes passed through the loops pass up the groins in front and the fold of the buttocks behind, and are attached to a waist-belt. One or two stitches may be introduced at the upper part of the wound and some gauze lightly packed around the tube and a dressing applied. The tube should be removed in four days and a large steel sound passed at the end of a week. Should any difficulty be experienced in passing this into the bladder a small gorget, or a grooved director introduced into the prostatic urethra through the perineal wound, will act as an efficient guide. A large silk-wove catheter should now be passed along the urethra into the bladder and tied in place, and the perineal wound allowed to heal. The retained catheter is removed in four or five days and a large steel sound passed a week later. Sounds should be passed at lengthening intervals after the operation.

EXTERNAL URETHROTOMY WITHOUT A GUIDE

Wheelhouse's operation. When the surgeon has failed to pass an instrument through the stricture the urethra may be opened in front of the narrow part and the opening searched for, and when this is found a fine probe may be passed through it and the stricture slit up upon it. This operation was first applied to this class of case by Arnott[1] in 1822. Wheelhouse[2] slightly modified the technique of the operation and it has been known by his name.

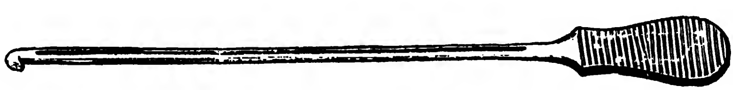


FIG. 313. WHEELHOUSE'S STAFF.

Wheelhouse's staff (see Fig. 313) is a straight instrument with a groove which stops short about ½ inch from the end. The rounded end forms a small projection on the side opposite to the groove.

Operation. The patient having been prepared for a perineal operation, Wheelhouse's staff is passed down to the face of the stricture with the groove towards the skin. An incision is made in the middle line of the perineum, which opens the urethra on the groove of the staff, and the tube is slit upwards towards the penis for about 2 inches. As the groove does not reach the end of the staff the incision is not carried right up to the face of the stricture, and the relation of the stricture to the rest of the urethra is thus preserved. The staff

[1] *Trans. Med. and Chirurgical Soc.*, vol. xii, 1822, p. 351.
[2] *Lancet*, June 24, 1876.

is now turned round and withdrawn so that the projection at the end hooks up the upper angle of the wound. The mucous membrane of the urethra is picked up with rat-tooth forceps on each side about the middle of the incision, and held out by assistants so that the urethra is fully exposed and slightly stretched. Instead of forceps held by assistants, a fine thread of silk may be passed through the edge of the mucous membrane on each side and this temporarily stitched to the skin. In practice Wheelhouse's staff often works badly as a retractor, and, indeed, it may be altogether dispensed with at this stage of the operation and the upper part of the wound left unretracted or hooked up by a blunt hook introduced from the surface. With a good head-light the surgeon now commences to look for the opening of the stricture, using a fine-grooved probe or a canaliculus director for the purpose. The thumb of the left hand may be placed in the lower angle of the wound and the stricture slightly everted by the fingers pressing on the perineum (see Fig. 314). Every tiny dark spot and depression is carefully probed and searched. The chief difficulty of the operation is the oozing which obscures the field with blood.[1] When this is trickling down

FIG. 314. WHEELHOUSE'S OPERATION. The urethra has been opened and the surgeon is searching with a probe for the lumen of the stricture.

[1] For this reason it is wise not to commence a Wheelhouse's operation at the end of a prolonged attempt to pass instruments. The operation should be postponed for a week or longer so that any oozing from laceration of the mucous membrane will have ceased.

from the upper part of the wound or the urethra beyond, a small plug of wool or gauze tucked in beneath the staff may control it. But the mucous membrane is often congested and friable and the oozing comes from the whole surface. A plug soaked in adrenalin will greatly assist the operation by blanching the parts and stopping the oozing, but this drug should be used with caution. The writer has experienced very severe post-operative hæmorrhage after a Wheelhouse's urethrotomy, which he attributed to a free use of adrenalin. The search may be prolonged and difficult. If the opening be not found on what appears to be the face of the stricture, the roof of the urethra should be systematically probed in front of this. The small openings of the lacunæ on the roof of the urethra are often deceptive. By making suprapubic pressure a few drops of urine may be made to escape from the lumen of the stricture, and betray its situation. It may happen that Wheelhouse's staff enters a very large old-standing false passage with a smooth lining, and as such a diverticulum is usually found on the floor, the opening of the stricture will be somewhere along the roof of this. The writer found in one case, where the search had to be abandoned and the urethra exposed by dissection behind the stricture, that a probe passed backwards through the stricture emerged in the urethra 2 inches in front of what was apparently the face of the stricture. The point at which the probe appeared was beyond the upper angle of the urethrotomy wound, and the staff had sunk for 2 inches into a large smooth-walled false passage below the stricture.

Having found, by diligent probing, the opening of the stricture lumen, the remaining steps of the operation are easy. The probe is passed through the stricture and the point of a knife follows this guide and cuts the stricture completely through on the floor. The portion of the urethra behind the stricture is usually dilated and a director or a gorget is readily passed into the bladder. A large catheter is now passed along the penile urethra and is guided into the bladder by means of the gorget. The perineal wound may be left without suturing, or one or two catgut sutures may be inserted to draw the edges of the urethra and the perineal tissues together. The catheter is tied in place and retained for four days, when it is removed. Some urine will probably escape from the perineal wound, if not during the retention of the catheter then immediately after its removal, but this ceases and in a few days the wound is dry. The passage of steel sounds is commenced ten or fourteen days after the operation.

Modifications. When the surgeon fails after a prolonged attempt to find the opening of the stricture several methods of procedure are open to him. It has been recommended that the stricture tissue should

be incised in the middle line until the lumen is reached. This method is not, however, likely to be successful in discovering the proper lumen of the stricture, although the urethra behind it may thus be opened. The new lumen that is formed in this way will pass through the fibrous tissue of the stricture and is very liable to recontraction.

If Wheelhouse's operation fails, one of three procedures may be adopted. 1. The urethra may be exposed behind the stricture by dissection and here opened. This is done by continuing Wheelhouse's incision backwards towards the anus, or, if the first median incision is far forwards, by making a second incision in front of the anus over the posterior extremity of the bulb, or a curved prerectal incision may be made so as to give free exposure for a careful dissection. In practice the latter incision is seldom necessary. The bulb is first exposed, and on reaching the posterior extremity of this the urethra is easily exposed at its membranous portion, since it is usually considerably dilated at this part. A probe is now passed penis-wards through the stricture and the scar tissue slit up from behind forwards upon this. A gorget or director is passed into the bladder and serves as a guide for a catheter passed as before.

2. The second method of procedure which has been practised in this dilemma is the so-called Cock's operation of perineal section without a guide.

Cock's operation. The forefinger of the left hand is introduced into the rectum and feels for the prostate. The pulp of the finger is placed upon the apex of that organ. A Cock's double-edged knife is now entered in the middle line of the perineum about ½ inch in front of the anus, the handle being held strictly in the horizontal plane. The knife is pushed onwards until its approach is felt by the rectal forefinger and it has reached the apex of the prostate. The urethra will now have been opened and the knife may be withdrawn, rocking it a little upwards and downwards so as to extend the superficial part of the wound. A probe-pointed director is now introduced into the wound and pushed on into the bladder, and this serves as a guide for the introduction of a perineal tube.

This operation was introduced by Cock for cases of acute retention in impassable stricture as an emergency operation. It was also used in cases where the perineum was much distorted by fistulæ and fibrous tissue. It has no advantage over the operation just described, and has the very grave disadvantage that it leaves the stricture untreated.

3. A third plan is to perform suprapubic cystotomy and retrograde catheterization. The bladder is usually distended with urine in the cases where this procedure is required, so that it is easily exposed and opened. After opening the bladder suprapubically, a metal sound is

passed along the urethra from behind forwards. Fuller[1] recommends the use of a Bénique's sound, which, on account of its full curve, is well suited for this purpose. It is made prominent in the perineum at the posterior surface of the stricture. The patient is then raised into the lithotomy position and the point of the sound is cut upon in the middle line of the perineum. An attempt can now be made to pass a probe forwards through the stricture so that it may be cut from behind forwards. If the probe cannot be passed through the stricture a sound should be passed down to the front of the stricture and the cicatricial tissue cut through in the middle line until this is exposed. The bladder is drained either through the perineal wound or through a catheter introduced along the urethra through the cut stricture and secured in position. The suprapubic wound is allowed to close. This operation is seldom necessary and has little to recommend it over the other methods just described.

Dangers. 1. *Hæmorrhage.* Severe hæmorrhage may arise either from the erectile tissue of the corpus spongiosum or from some vessel deeper in the perineum or at the neck of the bladder. The hæmorrhage may occur within a few hours of the operation, or it may commence eight or ten days later.

When hæmorrhage occurs the perineal wound should be opened up, and by turning out the clots some idea will be gained as to the probable source. A stream of hot lotion from an irrigator and a good head-light will greatly assist the search. Any vessel which is obviously bleeding is picked up. If a perineal tube be already in the bladder, strips of gauze should be packed around this. If a tube has not been tied in it should now be passed with the help of a gorget and the wound packed. A broad T-bandage allowing for the exit of the tube provides firm pressure on the perineum.

The remaining dangers of the operation are due to an exacerbation of previous disease as a result of the operation.

2. Cystitis and septic pyelonephritis.
3. Renal failure and uræmia.
4. Spread of septic inflammation in the pelvis or perineum.

Results. *Mortality.* It is hardly possible to quote figures which will give an accurate idea of the mortality of this operation compared with internal urethrotomy. For this there are several reasons.

(i) The individual surgeon practises one of these operations almost to the exclusion of the other, and if he favours internal urethrotomy the external operation will be reserved for the most serious cases.

(ii) The statistics which are given for internal urethrotomy are largely

[1] *Diseases of the Genito-urinary System*, 1900, p. 290.

those of stricture without local complications; those of external urethrotomy include a very large proportion of complicated cases.

The figures which follow must therefore be considered in that light.

At St. Peter's Hospital external urethrotomy or perineal section was performed in 100 cases with 8 deaths during a period of 13 years (1895 to 1908), and the patient died of the results of pre-existing disease, such as extravasation of urine and septic inflammation, in most of these cases.

The following statistics appear in the literature:—

Grégory[1]	992 cases	Mortality	8·8 per cent
Martens[2]	64 "	"	14·0 "
Horwitz[3]	116 "	"	4·3 "
Novotny-v. Antal[4]	80 "	"	3·75 "
Burckhardt[5]	25 "	"	12·0 "
König[6]	40 "	"	0 "
Gross[7]	26 "	"	3·8 "
Syme[8]	105 "	"	0·2 "
Thompson[9]	219 "	"	6·5 "
Nicolich[10]	20 "	"	0 "

Results. There is no greater certainty of curing a stricture by means of external urethrotomy than by other methods. The writer has met with a case in which no contraction of the urethra could be found with the urethroscope aided by air-distension two years after a Wheelhouse's operation. Most authorities agree that such cases may follow external urethrotomy. Post, van Buren, and Sayer[11] have seen patients twenty, twenty-one, and twenty-five years after external urethrotomy and found no recurrence. But the proportion of these cases is remarkably small when a large number of operated strictures is examined.

Where instruments are passed regularly after the operation the results are much better, and cases where a large instrument ($\frac{12}{14}$ or $\frac{14}{16}$ steel) is passed at intervals of some months and no recontraction is apparent are not infrequently observed.

Where the patient neglects regular dilatation, and where exposure and alcoholic excess are superadded, recontraction of the stricture becomes a certainty and it will become hard and cartilaginous in character.

[1] *Thèse de Paris*, 1879. This author states that the deaths which might directly be attributed to the operation amounted to 3·02%.

[2] *Die Verletzungen und Veränderungen der Harnröhre*, Berlin, 1902.

[3] *Journ. of Cutan. and Genito-urinary Disease*, 1898, p. 362.

[4] *Centralbl. f. d. Krankh. d. Harn- und Sex.-Org.*, ii. 336.

[5] Frisch und Zuckerkandl, *Handb. d. Urologie*, 1906.

[6] Quoted by Güterbock, *Krankh. d. Harnorgane*, vol. i, pt. 1, 1890.

[7] Quoted by Güterbock, *loc. cit.*

[8] *Stricture of the Urethra*, 1849.

[9] *Stricture of the Urethra*, 1885.

[10] *Wien. Med. Presse*, 1899, No. 50, 2083.

[11] Quoted by Heresco, *Comptes Rendus XIII^e Congrès Internat. de Méd.*, 1900.

There are cases, however, in which, notwithstanding regular habits and periodic instrumentation, the stricture slowly contracts after the operation, and a second cutting is required. In 100 cases of stricture attending my clinic at St. Peter's Hospital, external urethrotomy had been performed in twelve.

In 5 cases external urethrotomy had been performed once.
In 2 " " " " " " twice.
In 1 case " " " " " 5 times.
In 1 " " " " " " 6 times.
In 3 cases external urethrotomy was followed by internal urethrotomy at a later date.

The five cases where external urethrotomy had been performed once were those in which the best result had been obtained. Of these a 22 French bougie could be passed six months after the operation. Two patients could take a $\frac{13}{15}$ steel and a No. 19 French bougie respectively four years after the operation. One patient took a No. 16 French bougie nine years after the operation, and one a No. 10 French bougie seventeen years after the operation. In all these patients bougies had been passed regularly since. The attendance of the patient whose stricture only took a No. 10 French bougie was irregular. Two of these patients (Nos. 10 F. and 16 F.) would require a cutting operation again. In the patients who required a repetition of the operation, or have submitted to internal urethrotomy, there was invariably a history of neglect to have instruments passed after the operation.

These figures point to the conclusion that, although a few cures may be effected by means of external urethrotomy alone, the great majority require the regular passage of instruments after the operation, and any neglect of this will court recontraction.

EXCISION OF STRICTURES

A single stricture of moderate dimensions may be resected and the urethra united by sutures. The following is the technique of the operation:

Operation. The suprapubic and perineal regions are carefully prepared for operation. A preliminary suprapubic cystotomy is performed and a rubber tube fixed in position above the pubes. The patient is then placed in the lithotomy position and a metal instrument passed through the stricture. In the cases which are suitable for the operation the stricture can usually be felt from the surface of the perineum.

A median incision is made for about 2 inches with the stricture area as a centre. The corpus spongiosum is exposed and its sheath incised to

the full extent of the wound. Careful dissection now exposes the hard fibrous tissue of the stricture, and it may be so well defined as to be easily separated from the surrounding structures as a thick ring of yellowish white, almost cartilage-like tissue. This is carefully separated for the whole circumference of the urethra. In some strictures, and especially in those of traumatic origin, the fibrous tissue extends for some distance into the cavernous tissue of the bulb. The isolated ring of fibrous tissue is steadied while the urethra is cut across transversely in front and behind it. In order to carry this out the instrument which lay in the urethra may have to be removed. The cut ends of the urethra are now dissected up, and are freed so far as will allow the opposite edges to come in contact without the slightest tension being put upon the wall of the tube. A series of fine catgut stitches, commencing at the dorsum, is now introduced to bring the edges into apposition. The stitches pierce the whole thickness of the wall, and the edges of the mucous membrane are apposed as accurately as possible. After the first stitches are inserted, an instrument should again be introduced, and the rest of the stitching done with this as a splint. A gum-elastic bougie is more suitable than a metal instrument for this purpose. Having completed the suture, the bougie is removed and the structures superficial to the urethra are brought together with catgut sutures and the skin wound closed with silkworm gut. Care should be taken that the oozing from the corpus spongiosum and any other bleeding is stopped before closing the wound.

The suprapubic wound is drained by means of a suction apparatus for seven or ten days, when the tube may be removed. The foot of the bed should be raised so as to keep the urine as much as possible from the neck of the bladder.

A month after the operation the urethra should be examined with the urethroscope and a large steel bougie passed. If contraction has occurred at the site of suture regular dilatation should be commenced.

Some points are open to discussion.

(i) Most authorities on this subject recommend a retained urethral catheter, and do not drain the bladder suprapubically. The writer is strongly of the opinion that in order to attain a reasonable certainty of success in plastic operations upon the urethra suprapubic drainage must be used. The retained catheter, he believes, produces after forty-eight hours a certain amount of inflammation of the urethra, which is detrimental to healing, and after this time it is not a reliable method of bladder drainage, for it allows urine to trickle alongside it and soak the line of incision. Suprapubic drainage is a much more certain method of safeguarding the wound from infiltration of urine, but even with an open suprapubic wound a few drops of urine may sometimes find their way into the pro-

static urethra and be forced out of the external meatus. It is essential therefore to keep the bladder as dry as possible.

(ii) Catgut sutures are suitable for this work, and may be left to absorb or to come away in the urine later on partly absorbed, or are removed through the urethroscope. Buried sutures of fine silk are recommended by some surgeons. They must be inserted so that they do not pierce the mucous membrane of the urethra (Bousson,[1] Berg,[2] Thomas [3]).

(iii) The extent of tissue which has been removed from the urethra-wall has varied. Sometimes only a part of the circumference of the stricture is removed and the healthy mucous membrane stitched transversely. Guyon [4] operated upon a traumatic stricture in this manner. The writer resected a portion of a ring-like stricture of the penile urethra in the same way, and obtained primary healing. A steel bougie ($\frac{12}{14}$) passed easily before the patient left the hospital three weeks after the operation. Unfortunately all trace of the patient was lost.

An inch or an inch and a half of the urethra may be removed, and if the tube is freed for a sufficient distance on each side of the section, no tension is produced on uniting the ends. Burckhardt [5] has resected a length of urethra 6 centimetres (about $2\frac{1}{4}$ inches), and Goldman [6] excised a portion measuring 8 centimetres (about $3\frac{1}{8}$ inches). In the latter case the urethra was separated from the corpus cavernosum almost as far forward as the corona glandis. There was subsequent forward curving of the penis on erection, but this gradually disappeared. If the extent of urethral wall removed be such that after free preparation of each end of the urethra the ends will not meet without tension, some form of plastic operation will be required to make good the defect (see p. 600).

Results. The cases collected by Noguès [7] and Vignard [8] show that resection of stricture of the urethra in suitable cases is a successful operation, and that permanent cure of the stricture can thus be obtained. In fifteen cases there was no recurrence at the end of periods varying from six months to eight years.

Heusner [9] resected the stricture in a patient who died two and a half years later of kidney disease. At the autopsy only a linear scar was found at the site of resection.

[1] *Bull. et Mém. de la Soc. de Chir.*, 1896, p. 517.
[2] *Annals of Surgery*, 1903, No. 4.
[3] *Brit. Med. Journ.*, November 8, 1902.
[4] *Annales des maladies des organes génito-urinaires*, April, 1894.
[5] Frisch und Zuckerkandl, *Handb. der Urologie.*
[6] *Beitr. z. klin. Chir.*, 1904, vol. xlii, 230.
[7] *Loc. cit.*
[8] Quoted by Heresco, *Comptes Rendus XIII^e Congrès Internat. de Méd.*, 1900.
[9] *Deut. med. Wochenschr.*, 1883, No. 28.

A patient described by Horteloup[1] died three and a half years after the operation, and it was found that the perineal cicatrix was supple and there was no difference to be seen between the mucous membrane at the resected portion and that of the rest of the urethra. Tonnesco[2] describes two cases of resection where no recurrence of the contraction was observed one and a half and two years after the operation.

Rutherfurd[3] resected two traumatic strictures, removing $\frac{3}{8}$ and $\frac{1}{2}$ inch of the urethra and suturing the ends. One patient had a full-sized urethra seven years, and the other twelve months after the operation.

Watson and Cunningham[4] collected 64 cases of resection, but in only 13 of these was there any information in regard to the condition of the urethra more than a year after the operation. Of these the statement in 5 was only that the urinary stream or the urethral calibre was normal. In 3 cases the calibre one year after operation was 24, 26, and 27 respectively; in 3 cases examined fourteen months, fifteen months, and two years after operation, the calibre was 18, 22, and 23; and in 2 examined three, six, and one and a half years after operation, the calibre was 24 and 26.

THE SELECTION OF AN OPERATION IN STRICTURE OF THE URETHRA

Where a cutting operation becomes necessary the choice rests between internal and external urethrotomy and excision.

The following points may be considered :—

(i) *Position of the stricture.* A penile stricture is unsuitable for external urethrotomy, for a fistula is likely to follow the operation. Internal urethrotomy, either by Maisonneuve's or by Civiale's instrument, is preferable. The passage of instruments after operation must be commenced early in these strictures. If the stricture be near the meatus, a long thin blunt-pointed bistoury can sometimes be introduced along the urethra, and the stricture cut on the floor. Resection of a single well-defined stricture in this region may be successful.

Stricture in the bulbous urethra is suitable, so far as position is concerned, for any of the operative methods.

(ii) *Character of the stricture.* Soft annular strictures are specially suitable for internal urethrotomy followed by instrumental dilatation.

In a hard cartilaginous stricture internal urethrotomy will allow of a large ($\frac{14}{18}$) steel sound being introduced, and the progress depends upon the after-treatment by instruments. In similar manner the stricture will relapse after external urethrotomy if the regular dilatation by instruments be neglected. The writer has not met with a stricture too hard to be cut

[1] *Bull. et Mém. de la Soc. de Chir.*, Paris, 1882.
[2] Quoted by Heresco, *loc. cit.* [3] *Lancet*, September 10, 1904. [4] *Loc. cit.*

with a Maisonneuve instrument if the blade be keen. If the stricture be circumscribed and of cartilaginous hardness, and traumatic strictures specially conform to this type, resection of the stricture and immediate suture of the urethra may be performed and will be more likely to give a permanently successful result.

Multiple strictures of the urethra, which form much the greater number of strictures (73 % in the writer's cases), are unsuitable for external urethrotomy and for excision. Internal urethrotomy is the operation of choice in this type.

(iii) *Thoroughness of the operation.* If excision of the stricture be feasible, it is the most thorough of the three operations, but the fact that the great majority of strictures are multiple limits the application of this method.

External urethrotomy cuts through a much greater depth of tissue than internal urethrotomy. But with the exception of the cases of strictures which are complicated with fistulæ or are traumatic in origin, the urethrotome will cut to a sufficient depth to sever the whole of the stricture tissue. It is an almost invariable rule that in multiple strictures of the urethra the narrowest stricture lies nearest the bladder. In external urethrotomy this stricture is cut, but the strictures of wider calibre which lie nearer the external meatus are neglected. On this account the writer invariably performs a combined internal and external urethrotomy where an external operation is considered necessary. This combined operation was introduced by the late Mr. Reginald Harrison[1] in 1885, 'with the object of providing better drainage for urine and the discharges from a wound (internal urethrotomy), which can only be imperfectly treated antiseptically.'

(iv) *The duration of the convalescence.* To some patients it is an important consideration that after internal urethrotomy they can get about at the end of a week or ten days, while after external urethrotomy and resection they are confined to bed for fourteen to twenty-one days, or sometimes longer.

(v) *Danger of the operation.* In the mortality tables that have been given the danger of external urethrotomy appears to be far greater than internal urethrotomy. These figures are deceptive, however, for the cases submitted to external urethrotomy include the worst types of stricture and those complicated by abscess and extravasation of urine. External urethrotomy is probably somewhat more dangerous to life than internal urethrotomy, but not to the extent shown in these figures.

(vi) *After results.* Recontraction of a stricture takes place after both internal and external urethrotomy, and probably in about an equal

[1] *Brit. Med. Journ.*, July 18, 1885.

number of cases, and in about a similar time. The fact that in multiple stricture only the narrowest stricture is cut makes a relapse more likely in external urethrotomy.

(vii) *Stricture with complications.* A stricture with local complications, such as peri-urethral abscess, fistulæ, extravasation of urine, or urethral calculus, is best treated by external urethrotomy, and the combined operation of Harrison is useful in many cases.

Where chronic cystitis is present and thorough bladder drainage is desired, a large tube introduced through a perineal wound is a better method of obtaining it than a retained urethral catheter.

Where stone in the bladder is complicated by stricture and litholapaxy is the method of treatment which the surgeon proposes to adopt, internal urethrotomy should be performed in preference to perineal section as a preliminary to the major operation.

CHAPTER XX

OPERATIONS FOR THE REPAIR OF FISTULÆ AND ACQUIRED DEFECTS OF THE URETHRAL WALL

THE following preliminary statements may be made :—

1. Any urethral complication which accompanies the fistula must be rectified before attempting to repair the urethra. Thus a stricture must be freely cut and fully dilated before the urethroplasty is undertaken, and urethral calculi, which frequently complicate fistulæ, must be removed.

2. Efficient drainage of the bladder must be provided so as to avoid contact of the urine with the operation wound which closes the fistula. Suprapubic cystotomy is the only means of drainage that presents a reasonable certainty of success in plastic operations upon the urethra. Suprapubic drainage is therefore a necessary preliminary to the methods of treatment here described.

3. No attempt should be made to close a fistula while acute or subacute inflammation is present, and this especially applies to the fistulæ which follow the rupture of a peri-urethral abscess.

The operations will be considered according to the position of the fistula.

FOR FISTULÆ OF THE PENILE URETHRA

AT THE BASE OF THE GLANS PENIS

The following operation was described by Dieffenbach[1] :—

Dieffenbach's operation. The edges of the fistula are excised by a transverse elliptical incision (see Fig. 315, A) and the raw edges united by fine catgut sutures. Fine silk may be used and should be tied with the knot inwards. The ends of the sutures are drawn out through the external meatus and may be removed by gentle traction a few days after the operation. The under surface of the glans penis is now denuded of epithelium and a corresponding area is marked out by an incision on the under surface of the penis or the retracted foreskin, the two surfaces being base to base (see Fig. 315, B). The skin is dissected up from the foreskin or penis and turned forwards like a gangway, so that

[1] *Operative Chirurgie*, vol. i, p. 538.

it covers over the freshened surface of the glans, and is stitched in this position (see Fig. 315, C). A similar operation has been described by Loumeau, but, instead of turning over a flap of skin, an incision is

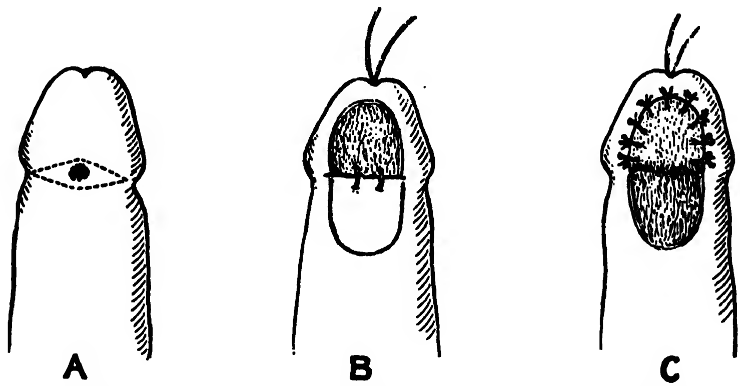


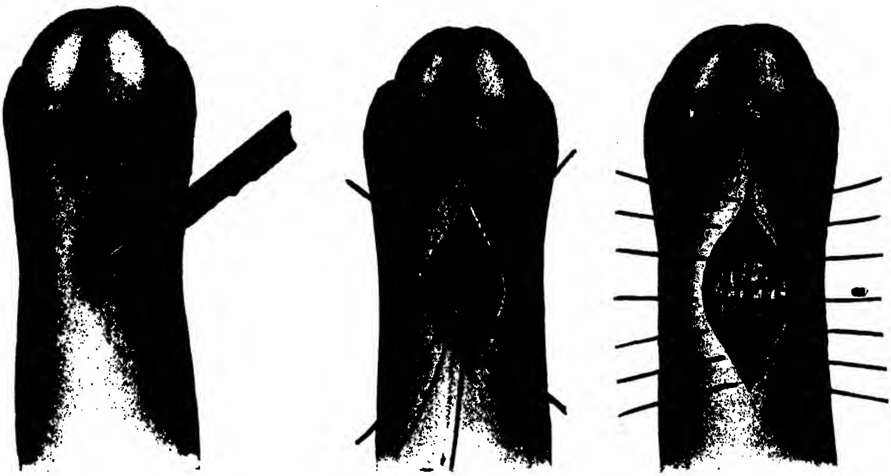
FIG. 315. DIEFFENBACH'S OPERATION FOR THE REPAIR OF PENILE FISTULA.

prolonged downwards from each of the lower angles of the denuded area and a flap of skin is dissected up. This flap is pulled up over the raw area and stitched in position.

ON THE UNDER SURFACE OF THE BODY OF THE PENIS

Operation. The following method has been adopted by the writer in several cases and has invariably proved successful: The skin and urethral mucous membrane are always united at the edges of a fistula in this position, and the intervening layers of tissue in the lips are very thin. With a fine knife the skin and mucous membrane are separated all round the edge of the fistula and the skin properly freed for some distance around (see Fig. 316, A). The mucous membrane is also freed. A series of fine catgut stitches is introduced, so that the mucous membrane is united transversely, and the tissues over this are drawn together by a second series of catgut stitches in the long axis of the penis (see Fig. 316, B). Finally the skin is united in the long axis of the penis with silkworm-gut (see Fig. 316, C). Healing by primary union usually follows. A very small opening may occasionally remain from the breaking down of one part of the wound, but this should heal spontaneously in a few days. No catheter is tied in, for temporary suprapubic drainage has been established.

Where the fistula is large and there is difficulty in obtaining apposition of the skin without tension, a longitudinal incision may be made through the skin on each side of the fistula. The edges of the fistula are now excised and the urethra stitched and the bridge of skin slipped



A B C

FIG. 316. OPERATION FOR PENILE FISTULA.

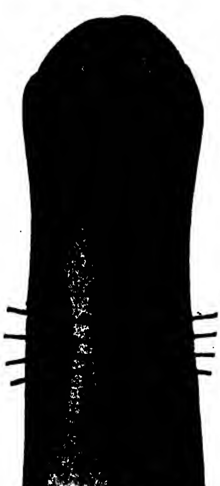


FIG. 317.
LATERAL BRIDGE
OPERATION FOR
PENILE FISTULA.

FIG. 318.
TRANSVERSE BRIDGE
OPERATION FOR
PENILE FISTULA.

FIG. 319.
SKIN-FLAP OPERATION FOR
PENILE FISTULA.

over the wound from each side and united over the closed fistula (see Fig. 317). Or a transverse incision may be made below the fistula and the transverse bridge thus obtained slipped forwards over the fistula (Dieffenbach); or a double transverse bridge of skin is used from above and below the fistula (Nélaton) (see Fig. 318), or a flap of skin may be turned over from the anterior surface of the scrotum to repair the defect after excision of the fistula (see Fig. 319). Guyon and Pasteau closed a large penile fistula by raising a flap of skin on either side. A longitudinal flap was raised from the skin below the fistula and left attached at its base. This flap was then turned over so that the skin surface formed the floor of the urethra at the fistulous opening. The lateral flaps were now brought together over this and the raw surfaces left by turning up the flap closed by stitches.

FOR FISTULÆ OF THE BULBOUS URETHRA

These fistulæ are almost invariably combined with stricture of the urethra and sometimes also with urethral calculus. The preliminary steps to the operation upon the fistula consist in an internal urethrotomy and, if a stone is present, in its removal.

FIG. 320. OPERATION FOR PERINEAL FISTULA. *First stage.* Incision round the opening of the fistula.

If a single fistula be present in the perineum it is the custom of the writer to dissect this carefully down to the opening in the urethra. A metal sound is placed in the urethra and the patient raised into the lithotomy position. An incision is made round the external opening of the fistula and carried forwards and backwards for about an inch in the middle line (see Fig. 320). The opening of the fistula is dissected free from the skin and firmly grasped in a pair of rat-tooth forceps and the dissection carried down outside the fibrous wall of the fistula, using sharp-pointed scissors and a fine knife, and taking care not to cut into the lumen of the fistulous tube. Bleeding is controlled by pressure with pledgets of cotton-wool on holders. By keeping along the edge of the

fibrous and healthy tissues a fibrous tube is gradually isolated and pulled out until the metal sound can be felt lying in the urethra (see Fig. 321). When this is reached the fibrous wall of the fistula is cut across and removed. Any hard fibrous tissue remaining at the edge of the opening in the urethral wall is clipped away. Several catgut sutures are introduced through the wall of the urethra, avoiding the mucous

FIG. 321. OPERATION FOR PERINEAL FISTULA. *Second stage.* Dissection of the fistula.

FIG. 322. OPERATION FOR PERINEAL FISTULA. *Third stage.* The fistulous track has been removed and stitches placed in the edges of the urethral wound.

membrane (see Fig. 322). These are tied and the perineal tissues are brought together over this with catgut sutures. A small drain is placed in the wound for two days and then removed.

Where multiple fistulæ open upon the perineum and scrotum without much fibrous induration, excision of the tracks should be attempted. The operation entails careful and painstaking dissection. These multiple fistulæ have usually one opening into the urethra. Some of the windings and side tracks of the fistulous system may defy dissection, and these must be scraped and all thickened fibrous tissue clipped away.

FOR PERINEAL FISTULÆ WITH LARGE MASSES OF FIBROUS INDURATION

Operation. In cases where there are fistulæ of the perineum and scrotum with massive formation of cartilaginous-like fibrous tissue, it should be the object of the surgeon to remove the whole of the fibrous mass. Dissection in these cases is out of the question. It is the custom of the writer to commence by performing internal urethrotomy and introducing a curved staff into the bladder. The patient is then placed in the lithotomy position and a vertical incision made in the median line of the perineum, and this is deepened until the urethra is exposed and the groove can be felt in the staff. A knife is now run along the groove and opens about 1½ inches of the urethra. A gorget is slipped along the groove into the bladder, the staff withdrawn, and a large rubber perineal tube introduced. The gorget is removed, the tube closed with a pair of pressure-forceps, and the excision of the nodular masses of fibrous tissue now commenced. The median perineal incision is continued forwards on to the scrotum as far as the nodular thickening can be felt (see Fig. 323). In doing this one or several collections of pus buried in the fibrous mass are exposed. The tissue cuts like a turnip, and the cut surface is opaque greyish white. An occasional artery spouts and is temporarily picked up in forceps. From the anterior end of the incision another is commenced which passes out on one or other side, keeping at the edge, or very near it, of the indurated tissue, and sweeps round on to the perineum. This is deepened, inclining inwards, so as to remove a great wedge-shaped mass of fibrous tissue which is held aside in toothed forceps as the incision deepens. Spouting vessels are picked up and the finger passed over the cut surface in search of hard nodules. Wherever an outlying mass of fibrous tissue is seen or felt it is freely removed. With it probably goes a small buried pus sac, or the end of a fistulous side track. A similar procedure is now carried out on the other side

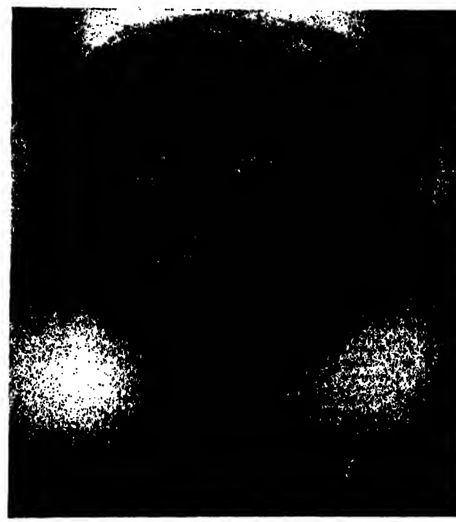


FIG. 323. INCISION FOR THE REMOVAL OF FISTULÆ AND MASSES OF FIBROUS TISSUE.

of the median line, commencing at the upper end of the incision and working downwards. In this way large fibrous masses, which cover an area the size of the palm of the hand and are several inches deep and thick, may be removed.

The next step is to repair as far as possible the defect left by this free removal of tissue. Commencing at the upper part of the wound, stout silkworm-gut sutures are introduced through the soft scrotal tissues from side to side and held up by an assistant. It is remarkable how little real loss of normal tissue there is, and how readily the skin comes together. When these sutures are tied, some part of the wound will probably not meet with the patient in the lithotomy position, but it will come together more easily when the thighs are adducted. Part of it will probably be left to granulate, and this is no great disadvantage. At the posterior part of the wound the skin again meets, and the tube should be secured in place by a suture passing through the skin on each side. The open part of the wound is lightly packed with gauze and a dressing applied and retained in position by a T-bandage.

After-treatment. The wound should be irrigated daily with a stream of biniodide solution. The bowels are kept confined for four days, and the tube is removed on the fourth day. At the end of a week or ten days a large steel sound is passed along the urethra and a gum-elastic catheter tied in for a week or more. Healing takes place in from three to four weeks, and the resulting scar is usually supple and healthy.

FOR THE REPAIR OF ACQUIRED URETHRAL DEFECTS

Autoplastic methods. The cases suitable for operation by this method are those in which some part of the urethral wall, usually the roof, remains intact, while a portion, sometimes very extensive, of the floor is wanting as a result of injury, extravasation, the removal of large calculi from the urethra, or other causes.

Two methods have been adopted, *viz.* (1) the undercutting and sliding together of skin and tissues on each side of the defect, and (2) the formation of definite skin flaps.

1. *The repair of the defect by undercutting and sliding.* An extensive defect of the floor of the urethra appears like a gutter with an opening at each end leading in the case of a perineal defect to the penile urethra in front, and the membranous urethra posteriorly. The skin and mucous membrane unite along each side (see Fig. 324).

A large bougie (No. 22 French) is passed along the penile urethra, appearing in the defect and disappearing into the membranous urethra. The urethra in front and behind the defect is first exposed and isolated

on its under and lateral surfaces for half an inch. This is done by making a median incision from the margin of the defect and dissecting on each side. An incision is now made through the skin along either side of the gutter and the skin and mucous membrane turned up over the bougie in two long flaps. At each end these lateral incisions pass into the wound made in dissecting out the urethra, and the end of this tube is now carefully pared. The lateral flaps are folded over the bougie

FIG. 324. EXTENSIVE DEFECT IN THE FLOOR OF THE BULBOUS URETHRA. (*Author's case.*)

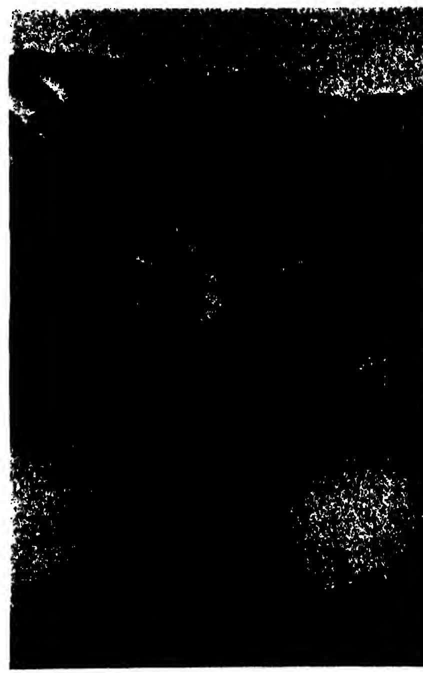


FIG. 325. RESULT OF OPERATION ON THE DEFECT IN THE BULBOUS URETHRA SHOWN IN FIG. 324. (*Author's case.*)

and meet each other in the middle line, and at each end are in contact with the pared end of the urethra. A row of closely-set Lembert's sutures of fine catgut unite the flaps along the middle line and transversely with the urethra at either end.

The next step is to unite the perineal tissues over this newly-formed urethra with a row of interrupted catgut sutures. This should be done without tension, and some undercutting may be necessary. The skin and subcutaneous tissues are now freed and united by silkworm-gut sutures. The instrument is removed from the urethra and siphon

drainage of the bladder through the suprapubic wound established by means of a White's apparatus (see Fig. 218).

After-treatment. The urethra should be left undisturbed and suprapubic drainage continued for a fortnight. After that time the suprapubic tube may be removed and the wound allowed to heal (see Fig. 325).

2. *Repair of the defect by double superimposed flaps.* The cases suitable for this method are the same as those for which the preceding operation may be used, but it is absolutely necessary here that the skin should be supple and free from hair. This method was introduced by Guyon,[1] who cauterized the skin before performing the operation, so that no hairs remained. The procedure is as follows: On one side of the urethral gutter a quadrilateral flap is marked out with its base on the inner side, and this is dissected up so that when it is turned over its cutaneous surface is buried and forms the floor of the urethra at the part which is deficient. A second flap, with its base outwards, is marked out on the other lip of the defect, and this is dissected up and is made to slide inwards across the middle line so as to cover the raw under-surface of the first flap, and the borders of this flap are stitched to the edges of the raw surface from which the first flap was turned over.

Heteroplastic methods. The cases suitable for this method are similar to those for which the autoplastic methods are used. Where the urethra has been completely divided or a segment of it destroyed by disease and a broad gap intervenes between the ends, the heteroplastic methods are especially indicated.

1. For the purpose of closing the gap portions of tissue from other parts of the patient's body have been used. Keyes,[2] von Frisch,[3] Leprévost,[4] and Mensel[5] have transplanted the inner surface of the prepuce into the urethral defect. Keyes cleansed the inner surface of the prepuce and packed it with antiseptic gauze. He then excised a stricture of the urethra and removed a portion of the inner surface of the foreskin 1½ inches by 2 inches in extent, and placed it in warm boric lotion. When the bleeding from the urethra had ceased, he stitched the portion of prepuce in position in the roof of the gap left by the removal of the stricture.

Albert[6] and Dittel[7] used strips of mucous membrane taken from

[1] Quoted by Albarran, *Médecine opératoire des voies urinaires*, 1909.
[2] *Journ. of Cutan. and Genito-urinary Diseases*, 1892, p. 401.
[3] *Internat. klin. Rundschau*, 1891, Nos. 26, 27.
[4] *Bull. et Mém. Soc. de Chir.*, Paris, 1890.
[5] *Berl. klin. Wochenschr.*, 1888.
[6] *Deut. militärärztl. Zeitschr.*, 1890.
[7] *Wien. klin. Wochenschr.*, 1895, No. 20.

the lower lip to close urethral defects. Lapiejko[1] operated in this manner on three cases, in one of which the defect of the urethra measured 7 centimetres. He stitched the transplanted membrane to the urethra in front and behind and laterally to the soft tissues of the perineum.

2. Portions of mucous membrane taken from other human beings have also been used.

Wölfler[2] excised the callous parts of the urethra in a case of old stricture and allowed the gap to granulate. He then took strips of mucous membrane several centimetres long and 1 to 2 centimetres broad from the mucous membrane covering a prolapsed uterus, and laid these on the granulating surface of the urethral gap without fixing them with stitches. A catheter was tied in position and the grafts were left undisturbed for five or six days.

3. Mucous membrane taken from animals and birds has been transplanted into gaps in the human urethra.

Results. In the autoplastic and also in the heteroplastic methods of repair, complete restoration of the urethral canal has frequently been obtained. There is some danger of contraction at the points of union of the repaired with the intact portion of the canal. Sometimes several operations are necessary before the defect is finally closed. Wölfler performed heteroplastic operations after excision of urethral stricture in three cases, and in two of these a No. 20 French bougie passed easily, and the patients required no further treatment with instruments. One patient died from nephritis six months after the operation, and on examining the urethra it was impossible to say where the transplanted portion of the urethra joined the proper mucous membrane. In Keyes's case there was some contraction of the urethra a year later, but a No. 21 French bougie passed.

Lapiejko found that in one of his cases of transplantation of mucous membrane from the lip the patient was well two years afterwards.

Pringle[3] found that transplanted urethra obtained from bullocks continued to live and the urine passed through it. He found difficulty, however, in obtaining complete union at the anterior point of junction of the ox and human urethral mucous membrane, and in two cases this did not heal. In his third case a second operation was successful in closing the fistula.

In one of his cases the transplanted urethra was excised on account of a persistent fistula, and replaced by another graft, and it was found that the tube, except at the fistulous opening, was healthy nineteen

[1] *Annales des maladies des organes génito-urinaires*, 1894, p. 41.
[2] *Archiv f. klin. Chir.*, 1888.
[3] *Annals of Surgery*, Sept. 1904.

months after implantation. Another of his three cases died from renal abscess, and it was hardly possible to make out the line of union of the mucous membrane of the graft and that of the original urethra.

FOR THE REPAIR OF URETHRO-RECTAL FISTULA

Not uncommonly there are other complications, such as congenital stricture of the urethra and sometimes also calculi, found in the bulbous or prostatic portions of the canal. These complications must first be treated and then the operation for the cure of the fistula undertaken.

Operation. The bowel should be prepared by purging and enemata for some days before. If possible a steel bougie is passed along the urethra into the bladder. Suprapubic cystotomy is performed, and a drain inserted. With the patient in the lithotomy position a curved prerectal incision is made extending well out on to the ischial tuberosities, and this is deepened by dissection through the tissues of the perineum. The bulb is identified and freed posteriorly, and is then hooked upwards, and the wall of the fistulous communication can now be felt. If this be broad and short with a direct communication between the urethra and rectum, the dissection must be carried laterally round the rectum so as to get well beyond the fistula on either side. If possible the dissection should be carried upwards beyond the fistula so as to isolate it, but in doing this the fistula may be opened. If this happens the edges of the opening must be picked up in catch-forceps and the opening enlarged so that eventually the fistula is cut across between the rectum and the urethra. Dissection is now carried further so as to separate the rectum from the prostate and bring the fistula well into view. This dissection may be very difficult, for the septum between the rectum and urethra immediately above the fistula may be very thin. In this case the separation of the rectum should be commenced well out on each side and carried towards the middle line. The next step is to close the openings in the rectum and urethra. The edges of the rectal opening are first trimmed, and a series of interrupted catgut sutures introduced through the wall, avoiding the mucous membrane. This is reinforced by a row of Lembert's sutures. The opening in the urethra is now trimmed, and a silk-wove catheter replaces the bougie. The edges of the opening are brought together over this by interrupted catgut sutures, which do not penetrate the mucous membrane, and a second row placed over this. A rubber drainage tube is placed in the middle line, and the muscular tissues of the perineum united with catgut sutures. The skin wound is closed around the tube. The catheter in the urethra is removed, and a siphon apparatus attached to the suprapubic drain.

After-treatment. The perineal tube is removed on the fourth or fifth day, and the bowels are kept confined for at least a week. The suprapubic drainage is continued for fourteen days, and then the tube removed and the wound allowed to heal.

If the fistula has a narrow track of some extent the operation is easier. A director should, if possible, be passed along the fistula from the rectum and acts as a guide. A thread of silk may be passed round the fistulous tube and tied, and the tube cut across close to the rectum and the stump covered with Lembert's sutures. Dissection of the tube is now carried down to the urethral wall, which is similarly closed.

Albarran[1] advocates a median incision passing forwards from the centre of the transverse parietal incision, where the fistula communicates also with the perineum. He also recommends that if there is inflammation or abscess formation the perineum should first be freely incised and the fistula opened up and scraped, and if the fistula does not close after this a second operation should be carried out. Ziembicke[2] and Fuller[3] make an incision round the anus and carry it forwards in the middle line on the perineum and backwards over the coccyx. The extra-peritoneal portion of the rectum is isolated, the fistula cut across and closed, and then the rectum is twisted round so that the urethral and rectal openings of the fistula are no longer opposite each other. The rectum is fixed in this position.

[1] *Loc. cit.* [2] *Semaine méd.*, 1889, p. 379.
[3] *Journ. of Cutan. and Genito-urinary Dis.*, April, 1897.

SECTION IV

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART VI

OPERATIONS UPON THE MALE GENITAL ORGANS

BY

F. F. BURGHARD, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to King's College Hospital; Senior Surgeon to the Children's Hospital, Paddington Green

CHAPTER XXI

OPERATIONS UPON THE PENIS

OPERATIONS FOR HYPOSPADIAS

Indications. Some form of plastic operation is required for all cases of defect in the floor of the urethra in which there is an impediment to the act either of micturition or coitus. There is no need to operate when the penis is moderately straight and has not undergone the downward deflexion commonly met with in marked cases of the deformity, neither is operation called for when the urethra opens at the base of the glans; in these cases the stream of urine can be projected normally and does not spray out and wet the patient as it does when recurvation exists. At the same time, however, it must be remembered that these are the easiest cases in which to secure a good cosmetic result, and the surgeon is not infrequently asked to operate upon them when the patient is grown up and is desirous of having the parts restored to their natural condition as nearly as possible.

When, however, the urethra opens further back than the junction of the middle with the anterior third of the penis, operation is always advisable. In most of these cases there is so much recurvation of the organ that the urine cannot be projected in an unbroken stream, but is sprayed out so that the parts are continually wet and in a state of chronic irritation that is most unpleasant and distressing; moreover, fertile intercourse is practically impossible.

The most suitable age for operation. As a rule, operation should be delayed until the patient is about six years of age; before that time the parts are so small and the inconvenience to the child is so slight as to render it unnecessary and inadvisable to endanger the chances of a successful result by operating when the parts are so delicate. The real difficulty in the operation lies in this smallness of the parts, which renders many of the operations recommended for this condition impracticable. It must also be remembered that it is difficult to repeat these operations, should they not be successful at the first attempt; the parts, already scanty, are occupied by dense fibrous tissue which effectually precludes the satisfactory raising of flaps and their accurate coaptation and suture.

When the urethra opens close to the root of the penis, and the organ is markedly recurved, it will be well to commence treatment when the child is about five years old; the first year may be devoted to straightening the organ (*vide infra*). A considerable time should be devoted to this part of the procedure, as the success of the rest of the operation depends largely upon it; as free incisions may have to be made, it is advisable that the cicatricial tissue resulting from them should have time to disappear as completely as possible before the final stages are undertaken, so that the parts may be supple and the flaps easily raised.

If the meatal orifice be immediately behind the glans, it is well to wait until the child is at least eight years old before operating. In this case even more than in the previous one it is most essential to have the parts as large as possible if the result is to be successful, and there is no objection to delay, since the child does not suffer from the abnormal position of the opening. In both classes of cases the operation should be practised before the onset of puberty. For this there are two chief reasons: the first and most important is that erections of the organ occurring after the operation in adolescents may seriously jeopardize the success of the operation, and the other is that the physiological development occurring at puberty materially helps to perfect the final result of the operation.

Methods of operating. The cases requiring operation may be divided into two groups, *viz.* those in which only the portion of the urethra traversing the glans is defective, and those cases in which the urethra opens on the under surface of the penile portion, generally near the peno-scrotal junction or even as far back as the perineum. In the latter group of cases the operative procedure usually consists of at least two stages, of which one is that for restoration of the glandular urethra.

FORMATION OF A NEW URETHRA IN THE GLANS PENIS

Much ingenuity has been expended on this operation and many unnecessarily complicated methods have been introduced. If a plastic operation be really required, which is generally only the case when it is to form part of a more extensive operation, the urethra in the glans penis can usually be restored by one of the following simple methods :—

From the redundant prepuce. When the urethra opens on the under surface of the base of the glans, the characteristic 'hooded' prepuce is present (see Fig. 326, A), and this may be made use of for repairing the urethra. This hood or fold of the prepuce overhangs the glans like a monk's cowl, and by putting it on the stretch and thrusting a narrow bistoury through it from the mucous to the cutaneous surface,

a large buttonhole-like aperture (see Fig. 326, B) is cut, and through this the glans itself is made to pass backwards as the hood of the prepuce is brought forward over it (see Fig. 326, C). The preputial flap thus becomes converted into a sort of apron below the frenal surface of the glans and can be utilized to furnish the floor of the new urethra, the roof of which

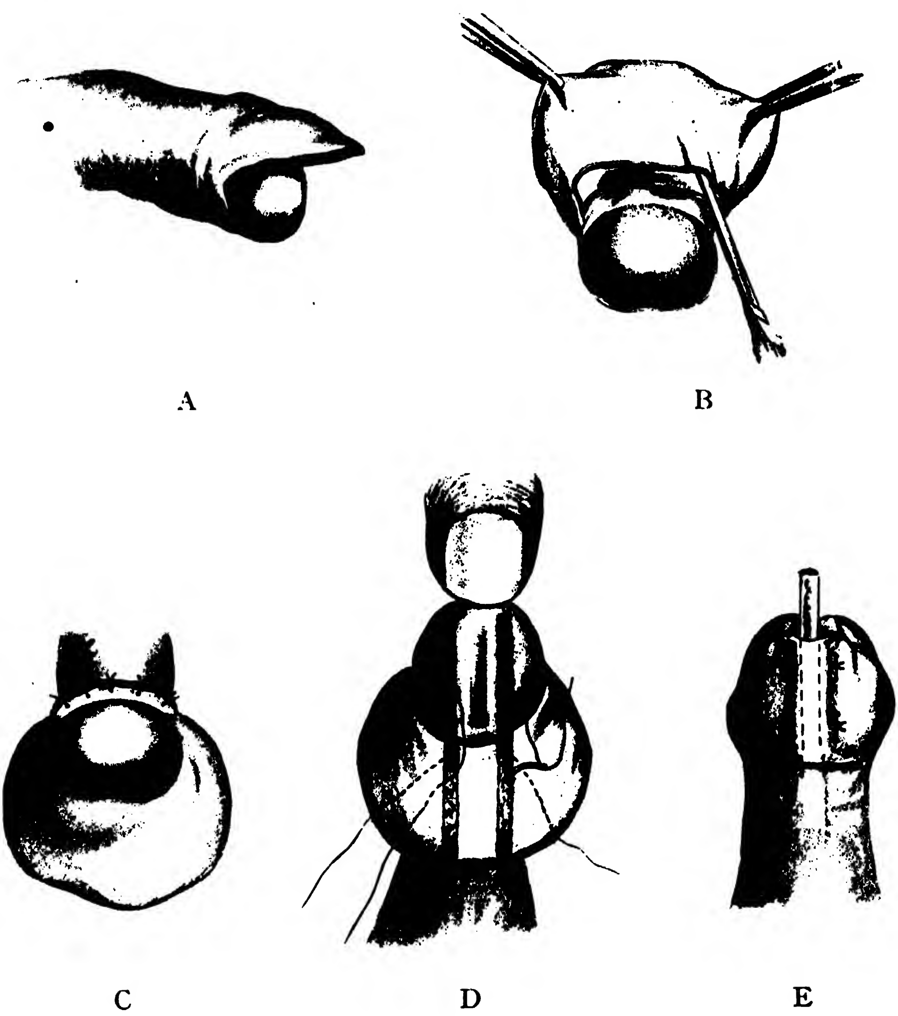


FIG. 326. REPAIRING THE PENILE URETHRA BY MEANS OF THE PREPUCE. A shows the 'hood' of redundant prepuce, B the incision made through it, and C the appearances when the glans penis has been passed through it. D shows the areas made raw upon the glans and the corresponding surfaces on the prepuce, and the method of inserting the sutures, while in E is seen the result when the sutures have been tied and the preputial flap trimmed up.

is provided by the slight groove which marks the normal situation of the urethra, and which is present even in the most severe cases.

A fine india-rubber Jaques's catheter (No. 6) is laid into this groove and its end is passed down the urethra for an inch or two; a narrow strip of the mucous membrane covering the under surface of the glans is then made bare on each side of the catheter from the level of the urethral orifice to the tip of the organ; the simplest way of doing this is to remove the mucous membrane with one snip of a fine pair of scissors. The flap or apron of prepuce is now laid over the catheter so as to form the floor of the urethra, and two small strips of skin are removed from it in a similar manner exactly opposite the raw surfaces already made on the glans (see Fig. 326, D). The raw surfaces on the glans on each side of the catheter are then approximated to the corresponding raw surfaces upon the preputial flap by fine horsehair sutures mounted upon the smallest fully-curved needles obtainable. Each suture should pass beneath the raw surface upon the glans parallel with its long axis, and the ends emerging from this should transfix the preputial flap at the corresponding points from its urethral to its cutaneous surface. Two or more of these sutures are passed on each side (see Fig. 326, E).

It now only remains to join the posterior or lower margin of the preputial flap to that of the abnormally situated meatus. The latter is seized with catch-forceps, and its inferior margin is put well upon the stretch and pared away with fine curved scissors. This separates the mucous from the cutaneous surface, and the corresponding margins of the lower edge of the preputial flap are sutured to these with very fine catgut. Special care should be taken to approximate the mucous membrane of the urethra accurately to the corresponding surface of the preputial flap. The sutures should be passed so that the ends emerge from and are tied on the under aspect of the penis.

The new urethral orifice may be fashioned to the operator's taste by making raw corresponding surfaces of the skin and the prepuce and suturing them together. It is well to make the new meatus unduly large, in order to allow for contraction. The catheter is secured in position by a single catgut suture passing through it and the adjacent prepuce.

After-treatment. No dressing is necessary. The child lies upon his back with a cradle to keep the bedclothes from contact with the parts, and his legs fastened to the cradle so that he cannot roll over on to his face; his hands should be tied so that he cannot interfere with the wound. He should have a warm bath twice daily, after which the parts should be dabbed dry and dusted with boric acid powder. Alternate stitches may be removed on the fourth day, and all the sutures may be

taken out by the end of the eighth day. The catheter over which the urethra is fashioned, which is secured in place by a single stitch passing through the preputial flap, should be kept in position for five days. It does not cause either cystitis or urethritis if the parts be thoroughly purified before the operation and if it be not passed down the urethra for more than 2 inches.

From the skin on the under surface of the penis. This is a very useful method for restoring the anterior end of the urethra in the minor degrees of the deformity in adults who desire the operation.

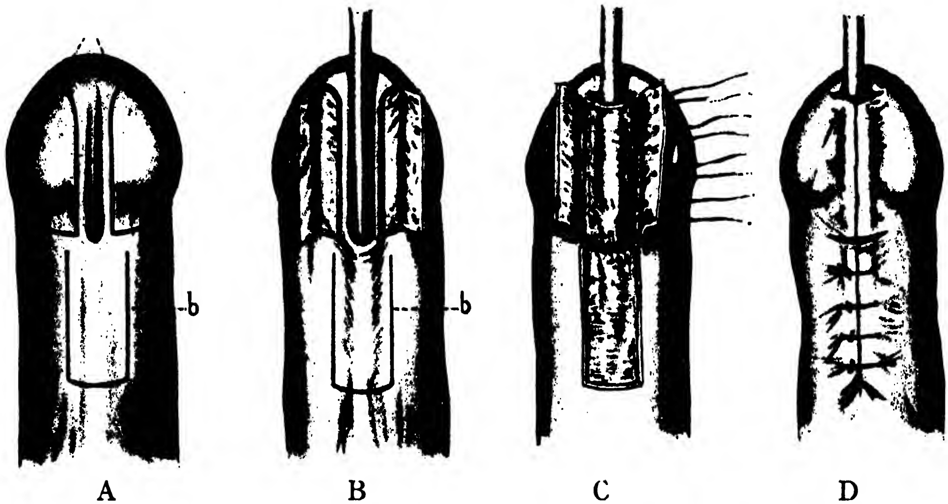


FIG. 327. REPAIRING THE PENILE URETHRA BY MEANS OF A PENILE FLAP. A shows the incisions for the flap *b*, as well as those from the glans *a*, beneath which the flap is to be placed. These flaps are shown reflected in B, while in C the penile flap is turned up into position and the retaining sutures have been inserted on one side. The result is shown in D.

It is simpler than the one just described, but it is only suitable for older subjects in whom the soft parts at the disposal of the surgeon are more voluminous. The operation consists in raising a rectangular apron-like flap of skin from the under surface of the penis below the urethral orifice, and turning this upwards over a catheter in the groove in the glans so that its cutaneous surface looks inwards and forms the floor of the new urethra (see Fig. 327, C). A small lateral flap is raised from each side of the glans and beneath these the apron-like flap is inserted. They are then brought together to form the outer or cutaneous covering of the new urethra (see Fig. 327, D).

The author has practised both these methods in suitable cases with

the best results; as far as his experience goes, one of them suffices for most cases of this type. Many others have been advocated, most of which have been tried with disappointing results. Beck's ingenious plan of freeing the anterior end of the urethra, dissecting it up for an inch or more, and then thrusting it through a tunnel bored in the glans with a trochar demands not only a urethra of good size and firm consistency, but also much operative dexterity and extreme delicacy of manipulation; sloughing of the isolated urethra may easily take place. The plan of Esmarch and Kowalzig (see Fig. 333), in which lateral incisions are made on the under surface of the glans, and between them a catheter is laid, and the edges of the gutter thus made are refreshed and brought together, is theoretically good but most difficult to carry into practice. Owing to the extreme tension, much granulation occurs even if no suppuration follows, and the new urethra is full of dense fibrous tissue.

FORMATION OF A NEW PENILE URETHRA

It is upon the cure of the more severe forms of hypospadias that the greatest ingenuity has been expended. The author has tried most of the methods, and has found nearly all of them open to serious objections. Duplay's classical operation, the details of which are shown in Fig. 328, which is so simple and apparently satisfactory on paper, is practically useless; the parts are too small and the tissues are not sufficiently abundant. It is often difficult to draw the flaps together without strangulating the penis, and some amount of sloughing is quite common in this form of operation. Hamilton Russell's method (*Brit. Med. Journ.*, 1900, vol. ii, p. 1432) is most ingenious, but the chance of sloughing of the narrow strips of skin out of which he fashions the new urethra is so great as to prevent the operation from coming into common use. C. H. Mayo (*Jour. Amer. Med. Assoc.*, April, 1901) fashions a tube with a cutaneous lining from the skin of the dorsum of the penis; this is drawn through from the dorsum to the neighbourhood of the urethral orifice beneath the skin, and, when its vitality is assured, its lower end is fastened to the urethra at a subsequent operation, while its upper end furnishes the new meatus. This is an operation of great delicacy and difficulty, and for reasons already given is hardly likely to be used frequently.

Straightening the penis. Before a plastic operation can be undertaken with any prospect of success, the penis must be straightened if it should have the characteristic recurved form often met with in hypospadias. This downward flexion of the organ is largely due to a thick band of fibrous tissue running along the middle line just below the septum between the corpora cavernosa; there may also be shortening of the under surface of the sheath of the corpora cavernosa

itself, and the effect of this is to bend the organ downwards so that the urine impinges upon the tip of the organ as it is ejected, and becomes sprayed out. Before proceeding to perform a plastic operation it is essential to straighten the organ, which may be effected by a judicious use of a tenotome. The penis is seized in the left hand and pulled straight so that the tense bands on the under surface are easily identified; they are nicked transversely in one or more places until the organ can be made to lie flat upon the abdominal wall without any tension. In some cases the skin of the under surface of the penis, corresponding to what will be the roof of the new urethra, is

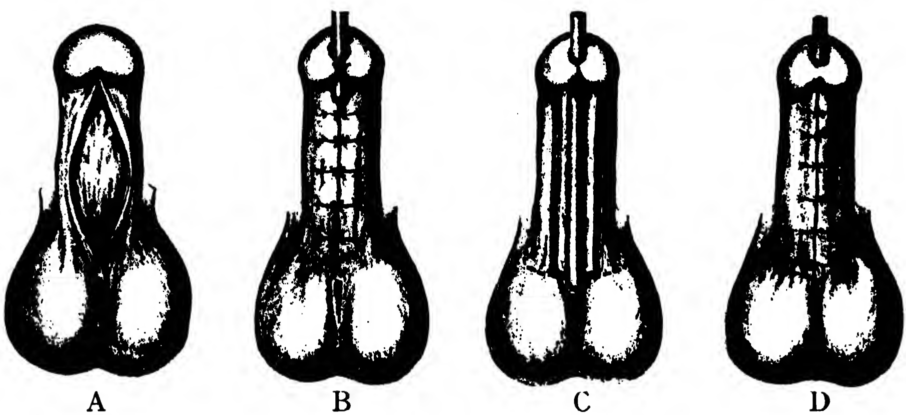


FIG. 328. DUPLAY'S OPERATION FOR HYPOSPADIAS. A and B show the preliminary stages, in which the penis is straightened and the urethra in the glans is repaired. The straightening is effected by a transverse incision which gives a lozenge-shaped space when the penis is pulled straight and is sewn up so as to produce a vertical cicatrix. C and D show the flaps raised on each side and united over a catheter and then covered in by drawing flaps across to meet over them.

so contracted that it must be divided also, and this, of course, gives rise to small diamond-shaped incisions when the organ is put on the stretch. These incisions are best closed by minute Thiersch's skin-grafts; it is well not to allow healing by granulation, as this is sure to be followed by re-contraction. The grafts, however, will not take satisfactorily unless the penis be kept in the straightened position, and, in order to ensure this, the author secures it to the abdominal wall by two sutures in such a way as to put the under surfaces of the corpora cavernosa fully upon the stretch. A fold of boric lint is placed between the abdominal wall and the dorsal surface of the penis, so as to prevent irritation from decomposing sweat. It is also a good plan to pass a rubber catheter an inch or so down the urethra, and to secure it there

by a suture; this enables the urine to be led away from the grafted area and considerably facilitates their taking. No dressing is applied; the bedclothes are kept from the parts by means of a cradle, and the child's hands are secured so that he cannot interfere with the wound.

This is an excellent way of performing an essential part of the operation, but it is important to take sufficient time over it and, if necessary, to perform it in several stages. The chief point to be guarded against is the production of granulating surfaces, since these will be followed by fibrous tissue which may take on a keloid character and so defeat the objects of the operation. If necessary, a year may be spent over this part of the operation.

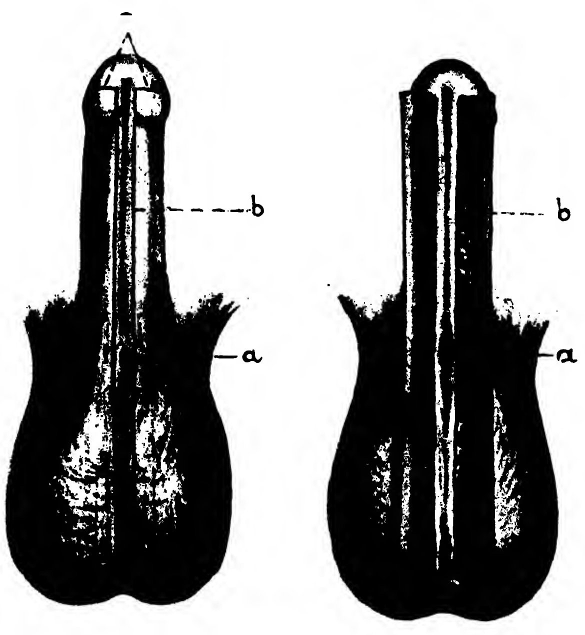


FIG. 329. BUCKNALL'S OPERATION FOR HYPOSPADIAS. *The incisions.* *a* is the urethral orifice, *b* the vertical, and *c* the horizontal incisions for the flaps.

Bucknall's operation. After trying all the operations enumerated on p. 614, the one that has given the most satisfaction in the author's hands is that suggested by Mr. R. T. H. Bucknall and described by him in the *Lancet*, 1907, vol. ii, Sept. 28. This has given admirable results in three cases, and the ease with which it can be done is in agreeable contrast to the difficulty of some of the other methods. The functional result is excellent, whilst the appearance of the organ after the operation leaves nothing to be desired. It is done as follows:—

First stage. The urethral orifice is taken as the fixed point, and from this incisions are made for equal distances (see Fig. 329, A) upwards and downwards. The incisions upwards run parallel to each other and to the long axis of the organ, and are at such a distance apart as the operator judges will give a sufficiently wide new roof to the urethra, which is to be formed by the skin of the under surface of the penis. On each side of these incisions narrow flaps are raised by carrying outwards,

from the upper end of each, horizontal incisions about ¼ inch in length. The vertical incisions are prolonged downwards over the anterior surface of the scrotum, at least as far below the urethral orifice as they extend above it, and similar flaps are raised by carrying horizontal incisions outwards at their lower ends. It is advisable to make the incisions below the urethral orifice slightly longer than those above it, in order to allow for the greater retractility of the scrotal skin.

The lateral flaps are dissected up on each side from the horizontal incision above to that below, taking care to raise them to the same distance throughout. They are then turned outwards so that the appearances seen in Fig. 329, B, are presented, *viz.* a narrow central strip of skin having the urethral orifice at its centre; the upper half of this forms the roof, the lower half the floor of the new urethra. Outside this is a broad raw surface, the outer vertical half being formed by the raw surface of the reflected flaps, the inner by the raw surface from which they have been raised. A No. 6 soft Jaques's catheter is now taken, and its end is cut off obliquely and inserted for ½ inch down the urethral orifice, which must be incised to admit it if necessary. The rest of the catheter is laid along the lower half of the median cutaneous strip, and the penis is brought down into contact with the scrotum so that the upper half of the median cutaneous strip lies over the catheter and forms the roof of the new urethra. The appearances seen in Fig. 330, C, are then presented, each lateral flap being flexed upon itself near its centre and forming a broad flange at the side of the penis.

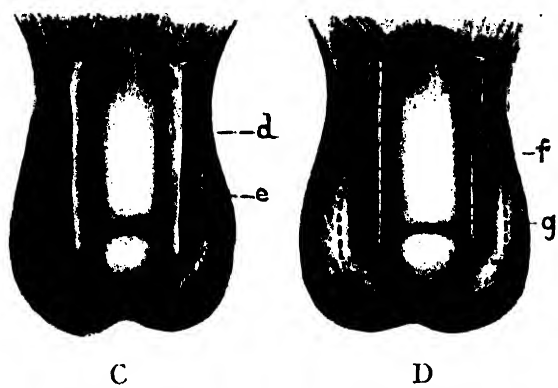


FIG. 330. BUCKNALL'S OPERATION FOR HYPOSPADIAS. *The penis secured to the scrotum.* *d* and *e* are the superposed edges of the flap *b* shown in the preceding figure. *f* is the drainage tube around which the sutures are fastened, and *g* is the scrotal incision for liberating the penis in the subsequent stage of the operation. For the sake of clearness the catheter is not shown *in situ.*

The next step is to suture the flaps, which must be done with great care, as the sutures must not only fasten each lateral skin flap, but must also approximate the margins of the median cutaneous strips above and below so as to form a complete urethra surrounding the catheter;

Fig. 331 shows how this is done. The sutures, which should be of the finest horsehair mounted upon the smallest needles obtainable, are first introduced from the under surface of one of the lateral flaps or flanges near to its angle of reflection. It emerges from the raw surface and is made to pick up the adjacent margin of the inferior median cutaneous strip; it then takes up the corresponding edge of the upper median cutaneous strip, passes from the raw to the cutaneous surface of the upper half of the lateral flap or flange, and is finally made to transfix both halves of the lateral flap or flange from the upper to the lower cutaneous surfaces just external to the point at which it was introduced (see Fig. 330, D). About four or five of these sutures are introduced on each side, and it is well to keep the ends long until they are all in position so that accuracy of insertion may be ensured. Finally, they are tied over a fine piece of drainage tube.

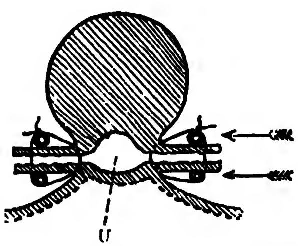


FIG. 331. BUCKNALL'S OPERATION FOR HYPOSPADIAS. *The arrangement of the sutures.* *u* is the lumen of the newly formed urethra. The arrows point to the pieces of drainage tube over which the sutures are tied.

If desired, the edges of the groove in the glans penis can be made raw and sutured to a corresponding raw area where it lies in contact with the scrotal skin; but as a rule this is best left to a later stage of the proceedings, when one of the operations previously described can be adopted.

The catheter is secured in position by a fine horsehair stitch and is left long enough to drain into a bottle. The child is put back to bed without any dressings, the bedclothes being kept off by a cradle over the pelvis and the hands being fastened out of the way.

No special after-treatment is necessary. The sutures are retained in position until the fifth day, when alternate ones may be removed; on the seventh or eighth day they may be all removed if primary union has occurred. The catheter may remain in for a week; it does not give rise to any inconvenience.

Second stage. The result of the first stage of the operation is to fix the penis firmly to the anterior surface of the scrotum, at the same time providing a tube or tunnel lined with epithelium throughout, along which the urine can pass, and which is continuous behind with the normal urethra without the intervention of any stricture or diverticulum. The object of the second stage of the operation is to raise the organ into the erect position, free it from the scrotum, and, at the same time, provide its under surface with a cutaneous covering.

With this object in view, the incisions shown in Fig. 330, D, are made;

they should go well wide of the margin of the penis and should be parallel to it and of the same length. By following Mr. Bucknall's description in the first case done by the author it was found that these lateral flaps were not wide enough to allow them to be folded round the under surface of the freed penis so as to meet in the middle line without tension. They should be made very wide, as it is most important that they should meet without any tension, and it is immaterial to the union of the wound in the scrotum how wide they are.

When these flaps have been raised, the penis must be separated from the scrotum by a little careful dissection, during which it is advisable to insert a fine bougie down the urethra in order to define it and so avoid button-holing it when dissecting up the penis.

The operation is completed by wrapping the scrotal flaps around the body of the penis and suturing them together in the middle line (see Fig. 332, E). The raw surface on the scrotum is closed by a few sutures, and the raw surface left at the angle of reflection of the penis from the scrotum is sutured as shown in Fig. 332, F.

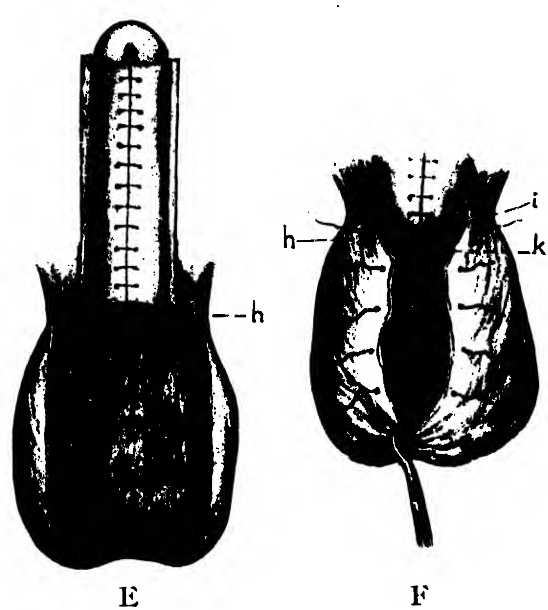


FIG. 332. BUCKNALL'S OPERATION FOR HYPOSPADIAS. *Final stage.* Shows how the new urethra is closed in by flaps dissected up from the scrotum. The raw area, *h*, must be carefully closed by suturing the edges of the skin, *i* and *k*.

No catheter need be used, as the patient can micturate normally; no dressing is necessary, as the penis maintains an erect position. The sutures are removed at the end of the week, and the fashioning of the urethra in the glans can be undertaken as soon as union has occurred throughout.

This operation is very simple and easy to perform when a thorough understanding of it has been acquired. It seems to be quite an ideal operation for those cases in which the urethra opens at the peno-scrotal junction; in two cases of this kind done by the author the result was perfect. When the opening is further back in the perineum the operation

is more difficult, but the idea of providing a complete cutaneous lining to the urethra continuous with the normally existing one is an excellent one, and does away with one of the greatest objections to other plastic operations of this kind.

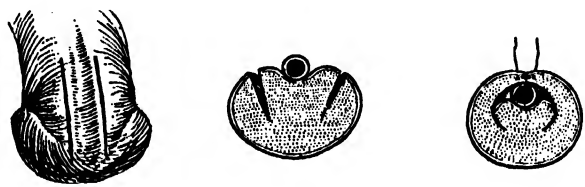
Difficulties. The only practical difficulty met with in the operation was making the scrotal flaps meet around the penis in the final stage of the operation. As mentioned above, this was subsequently overcome by cutting much wider flaps than those originally suggested by Mr. Bucknall. A theoretical objection which occurs to the author, but which there has not yet been time to verify by experience, is the possibility of the development of hairs along that portion of the floor of the urethra derived from the median raphe of the scrotum. It is possible that this may not occur, partly from the fact that hairs do not develop freely along the raphe, and partly on account of the early stage at which the operation is performed; but, should experience show that this does occur, the author would suggest that it can be easily remedied in future by first preparing a surface free of hairs along the median raphe by means of Thiersch's skin grafts. When this has become properly established it will be easy to perform the operation in the usual manner and there will then be no possibility of hairs developing.

OPERATIONS FOR EPISPADIAS

This condition is much rarer than the preceding one and is far less amenable to treatment. The deformity is always more marked, the penis being rudimentary and recurved upwards, and the affection is almost invariably associated with ectopia vesicæ. As has been pointed out by Mr. Thomson Walker (see p. 479), a plastic operation having for its object the restoration of the vesical cavity cannot provide a satisfactory sphincter vesicæ, and therefore complete functional restoration of the penis and its urethra is an impossibility. The surgeon's aim is merely to provide a channel down which the urine can be conducted to the urinal which the patient has to wear for the rest of his life. This of course only applies to the operations that aim at restoring the vesical cavity. In the more modern methods, in which the bladder is extirpated and the ureters are implanted into the rectum, plastic operations upon the urethra are not called for.

As in the operation for hypospadias it may be necessary to divide the procedure into two stages, the first being straightening the stunted and recurved penis, while the true plastic operation is performed at the second. Straightening the penis is far more difficult and less satisfactory in epispadias than in hypospadias. In spite of free division of the corpora cavernosa it is extremely difficult to keep the organ properly stretched

during the process of cicatrization, and, as suppuration and free granulation commonly result from the irritation to which the wound is subjected, the after-condition is worse than before the operation. If the operation be attempted, its main lines will follow those of the operation for hypospadias. The closure of the urethra cannot well be effected by any modification of Bucknall's method (see p. 616), since the middle line of the abdomen is occupied either by the protruded mucous membrane of the bladder or by the cutaneous flaps which cover it in ; therefore Duplay's classical method is usually followed (see Fig. 328), the flaps being taken from the dorsal instead of the under surface of the penis. For reasons already given (see p. 614) this method is unsatisfactory, and the author



A B C

FIG. 333. FORMATION OF THE URETHRA IN CASES OF EPISPADIAS. In A are shown the incisions, which extend deeply, as seen in B. The catheter is then laid in position, and the final stage is seen in C.

has on one occasion formed a covering to the urethral groove by superposed skin flaps turned in, one from either groin. The flaps were cut with a long pedicle which was left unsevered until they had become firmly adherent in their new position, when they were trimmed off in the usual manner. The first flap had its cutaneous surface downwards and its raw surface upwards, the second was applied so that its raw surface was in apposition to the raw surface of the first and its cutaneous surface was therefore outwards and formed the skin of the penis. The result was not very sightly, but was quite efficient.

If it be desired to form a fresh urethra through the glans, this may be done by the same flap, or by the method of Esmarch (see Fig. 333).

The proximal end of the newly formed urethra requires to be joined up to the reconstituted bladder-wall. This may be done at the time the new urethra is formed, but, on the whole, it is better to postpone it until healing of the flaps has taken place. A catheter is then introduced into the bladder, or preferably a median perineal section is performed and the urine drained away; the adjacent margins of the urethra and the skin covering the bladder in the region of its anterior wall are pared and sutured with fine horsehair.

CIRCUMCISION

Indications. (i) *Phimosis.* Although the operation is frequently recommended for all cases of phimosis whatever their degree, and although there is much to be said in favour of operation in these cases from the point of view both of cleanliness and morality, it is by no means absolutely necessary except when the preputial ring, *i.e.* the junction of the mucous with the cutaneous surface, is normally, or has become pathologically, so narrow and unyielding that it is impossible to withdraw it over the glans. A long narrow prepuce does not *per se* require to be removed, although extra care is required for proper cleanliness and to avoid balanitis. Should this latter condition supervene, the first effect of the inflammation is to thicken the prepuce, to make its orifice relatively narrower, and to convert the case into one of acquired phimosis. Unless the prepuce be slit up, severe ulceration possibly ending in gangrene may occur. This, however, is not a true circumcision, which should not be done under these circumstances (*vide infra*).

(ii) *Soft chancre beneath a long prepuce.* Here the conditions are very similar to those in balanitis beneath a redundant prepuce, but the danger of gangrene is greater. In some of these cases circumcision allows the soft sore to be excised completely along with the redundant prepuce, but as a rule simple slitting up of the prepuce is to be preferred to circumcision (*vide infra*).

Contra-indications. It is not advisable to do a complete circumcision when there is acute inflammation going on beneath the prepuce; the most that should be done in these cases is to slit up the prepuce so that free drainage and proper exposure of the subjacent parts may be secured. Infection of the cut surfaces is almost certain to occur, and, if a complete circumcision has been done, this may result in a foul wound encircling the whole organ, giving rise to wide destruction and serious cicatrization afterwards.

This operation should always be done at the earliest age possible; if performed a few days after birth there is hardly any disturbance following it, and it is extremely simple, provided that great care be taken to arrest all bleeding before the patient is left, as hæmorrhage is most dangerous at such an early age. In an adult the operation is more troublesome, chiefly on account of the variations in size of the organ subsequently.

Operation. This small operation, which is generally left to dressers and house surgeons, is difficult to perform really neatly and satisfactorily; the most common defect in the operation is the presence of a tender

redundant mass in the neighbourhood of the frenum, which may granulate for weeks before healing takes place; it disappears very slowly but eventually becomes unrecognizable. A line of ulceration surrounding the penis owing to imperfect union of the flaps is another objectionable feature not infrequently seen.

It is probable that the classical method of performing this operation is somewhat to blame for the ugly results so often seen. In this plan the separated blades of a pair of dressing forceps are made to embrace the glans penis parallel to and immediately in front of the corona. The blades are gently closed upon the skin, in doing which the glans is allowed to slip back so that when the blades are closed they press the prepuce together in front of it. The portion of the prepuce in front of the forceps is shaved off with a sharp knife, and the forceps are then removed and the shortened prepuce is allowed to retract. This exposes the corresponding mucous surface of the prepuce which has not been divided, and this is slit up from the preputial orifice back to the level of the skin section and the redundant portion pared away. The skin and mucous surfaces are then brought into apposition throughout by fine sutures of catgut or horsehair.

There are two objections to this method. The first is that the mucous membrane must be cut in a slanting direction from behind downwards and forwards towards the tip of the organ; in other words, the line of section must be parallel to the corona. If care be taken to place the forceps parallel with the corona and to keep them so during the approximation of their blades, it is possible no doubt to make the line of section correctly and to divide the mucous membrane subsequently so that the mucous and cutaneous surfaces will meet everywhere without tension and without the risk of leaving a raw granulating surface in the neighbourhood of the frenum; even then, however, it is necessary to insert sutures in the neighbourhood of the frenum, and these are irritating and are followed by the formation of a tender swelling. The second objection is that with this method it is difficult to gauge the exact amount of tissue that should be removed. The amount actually removed will vary largely according to the state of the organ at the time of the operation; on the one hand, it is common to see so much removed that the organ is almost bereft of skin, while on the other, most surgeons have been called upon to operate a second time owing to the fact that after the first operation the glans has retracted beneath the skin, which has then become contracted in front of it, giving rise to a secondary phimosis. Another less important objection is that a beginner may press the blades of the forceps too tightly together and damage the skin so much that it sloughs subsequently. This error can be avoided by placing the forceps a little

further forward on the prepuce and cutting through the latter *behind* their blades instead of *in front* of them, so that the compressed portion of the prepuce is removed along with the free end.

The method which offers the best results even in the most inexpert hands is the following: After the patient has been anæsthetized, a pair of catch-forceps is placed on the preputial orifice on each side of the mid-dorsal line, and a probe or the closed blades of a pair of fine blunt-pointed scissors are inserted between it and the glans and pushed backwards to the corona so as to separate any adhesions between the two. Then, while the assistant pulls the forceps well forward, one blade of the scissors is

FIG. 334. PARING AWAY THE PREPUCE IN CIRCUMCISION.

passed beneath the prepuce and the other above it and the foreskin is slit up in the middle line right back to the corona with a single cut; this divides the mucous and cutaneous surfaces back to the same level. The two preputial flaps are now reflected, all adhesions between them and the glans separated, and any retained smegma removed. It will then be seen how much of the redundant tissue need be removed; as a rule very little suffices, and it is always advisable to leave enough to just cover the corona so as to prevent undue irritation. In order to pare off the redundant prepuce the parts should be put on the stretch as shown in Fig. 334, and the surgeon, using a pair of blunt-pointed fine curved scissors, pares away as much of both the cutaneous and the mucous surfaces of the prepuce as he deems necessary parallel to the corona.

As the scissors travel round from the dorsum to the frenum they approach more nearly the free margin of the prepuce, and it is a good plan not to carry the incision quite up to the middle line of the frenum; if it be made to terminate about a sixth of an inch from the middle line on each side, the terminal branches of the frenal artery are not divided and there is no necessity to insert sutures in the immediate neighbourhood of the frenum, which avoids a good deal of swelling and irritation.

After the mucous membrane has been pared away on each side, a few fine horsehair or catgut sutures, preferably the latter, bring the edges into accurate apposition. This is quite easy, since the cutaneous and mucous surfaces have been everywhere cut on the same level. About six sutures suffice in a young child, but a larger number should be used in an adult, as it conduces greatly to the success of the operation to have the raw edges in apposition everywhere. In a child no dressing is necessary; a warm boric fomentation is laid over the genitals and is renewed every time the child's diaper is changed. In an adult a strip of dry sterilized gauze may be wound round the incision and allowed to dry on; this dressing may be soaked off next morning in the bath. After this it will only be necessary to apply a little boric acid powder and wrap the organ loosely in gauze to prevent chafing.

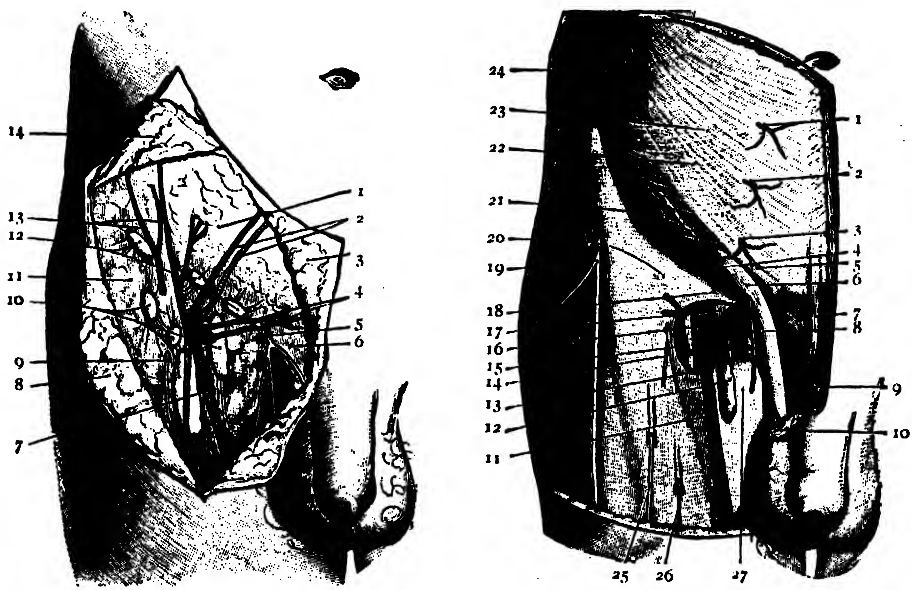
After-treatment. An adult should remain in bed or on the couch for four or five days with the parts protected by a cradle and the penis resting upon a few folds of boric lint. In an infant the ordinary routine of life need not be interrupted after the anæsthetic has been recovered from. The sutures, if of catgut, will probably soften and fall out spontaneously; if they have not separated by the fourth day they should be removed in the case of an infant, while in an adult they may be retained until the end of the week. In adults also the bowels must be carefully regulated, and it will be well to insist on a low diet without alcohol; the administration of a nightly draught containing bromide of potassium and other sedative drugs is valuable, as it tends to subdue erections.

AMPUTATION OF THE PENIS

Indications. Epithelioma is the only condition for which amputation of the penis is likely to be required, but there are two points of much interest which have to be taken into consideration before the surgeon operates. The first question is the form that the amputation shall take in any given case, and the second question is whether the inguinal glands should be removed at the time of the operation whether they be enlarged or not.

The type of operation required will be determined largely by the extent

of the disease when the case comes under notice. The penile lymphatics are collected into two main groups, a very extensive one from the glans and a network from the skin, both of which empty into large lymphatic trunks which follow the dorsal vein of the penis and at the root of the



B

FIG. 335. THE SUPERFICIAL AND DEEP INGUINAL LYMPH GLANDS. A, *The superficial glands*: 1, Deep layer of the superficial fascia; 2, Superficial epigastric vessels; 3, Superficial layer of the superficial fascia; 4, Superior external pudic vessels; 5, Ilio-inguinal nerve; 6, Spermatic cord; 7, Internal saphenous vein; 8, Superficial layer of the superficial fascia; 9, Genito-crural nerve; 10, Femoral glands; 11, Deep layer of the superficial fascia; 12, Inguinal glands; 13, Superficial circumflex iliac vessels; 14, Superficial layer of the superficial fascia.

B, *The deep lymphatic glands*: 1, 2, 3, Cutaneous branches of the lumbar nerves; 4, 5, Pillars of the external abdominal ring; 6, Spermatic cord; 7, Suspensory ligament of the penis; 8, Ilio-inguinal nerve; 9, Penis; 10, Scrotum; 11, Internal saphenous vein; 12, Deep femoral gland; 13, Saphenous opening; 14, Genito-crural nerve; 15, Femoral artery; 16, Femoral vein; 17, Crural sheath; 18, Falciform ligament; 19, External cutaneous nerve; 20, Iliac portion of the fascia lata; 21, Poupart's ligament; 22, Intercolumnar fascia; 23, External oblique aponeurosis; 24, External oblique muscle; 25, 26, Middle cutaneous nerve; 27, Pubic portion of the fascia lata. (*Cunningham.*)

organ pass on each side to the inguinal and external iliac glands. The lymphatics from the skin empty into the superficial inguinal glands, whilst those from the glans pass into the deep inguinal group and thence into the external iliac glands through the crural canal.

It follows from these considerations, therefore, that it is unnecessary to remove the entire organ if only the free end of it be involved, and, as the disease usually starts in the neighbourhood of the glans, a partial amputation is nearly always sufficient. If the amputation be performed ¾ inch behind the furthest limit of the growth it will suffice. The entire organ need only be removed when the disease has spread so far back that it is impossible to get well free of it without detaching the crura from the rami of the pubes.

The question as to the removal of the inguinal glands is one that has only come into prominence recently. The distribution of the penile lymphatics has been given above, and the positions of the inguinal glands are shown in Fig. 335. From a consideration of these facts, it is evident that operations for cancer of the penis cannot be satisfactory unless undertaken before the infection has passed from the deep inguinal glands to the external iliac group through the crural canal; when this has happened, the disease has passed beyond reach. Therefore the inguinal glands should be removed in all cases of cancer of the penis, whether they be enlarged or not. It would no doubt also be better to remove the lymphatics from the dorsal surface of the penis at the same time, but this is obviously a matter of difficulty, and in practice is apparently not necessary. Advantage should be taken of the incision for the removal of the inguinal glands to excise the lymphatic area in the skin, passing from the dorsum of the penis to the superficial inguinal glands.

PARTIAL AMPUTATION OF THE PENIS

Indications. (i) *Cancer of the penis not extending further back than 1 inch from the corona.*

When the disease extends further back than this, the complete operation (*vide infra*), followed by suture of the urethra to the skin of the perineum, will probably be preferable to the discomfort which is likely to ensue if the penis be amputated at the peno-scrotal junction, as this leads to great retraction of the urethral orifice and constant trouble in micturition.

(ii) *Extensive warty growths in the penis in elderly patients.* Here the operation may be done to free the patient from a constant source of trouble and a fruitful cause of malignant disease.

The simplest method of amputating the penis is to make a circular sweep around the organ, dividing all the structures at one cut. This, however, leaves a puckered cicatrix that it is difficult to adjust properly and in which granulation may exist for a considerable time before healing is complete; moreover, since the urethra is in the centre of this area, considerable contraction of the orifice may result.

Amputation by a ventral flap. A better procedure is to fashion a single flap, either from the dorsal or, preferably, from the ventral aspect of the organ; this can be folded over the end of the stump, and provides a satisfactory covering for it. Most surgeons recommend a flap cut from the dorsal surface, but the author prefers to fashion it from the under surface, because the line of union of the flap is thus removed from contamination by the urine during micturition; the point, however, is not of material importance. A ventral flap should be used when the

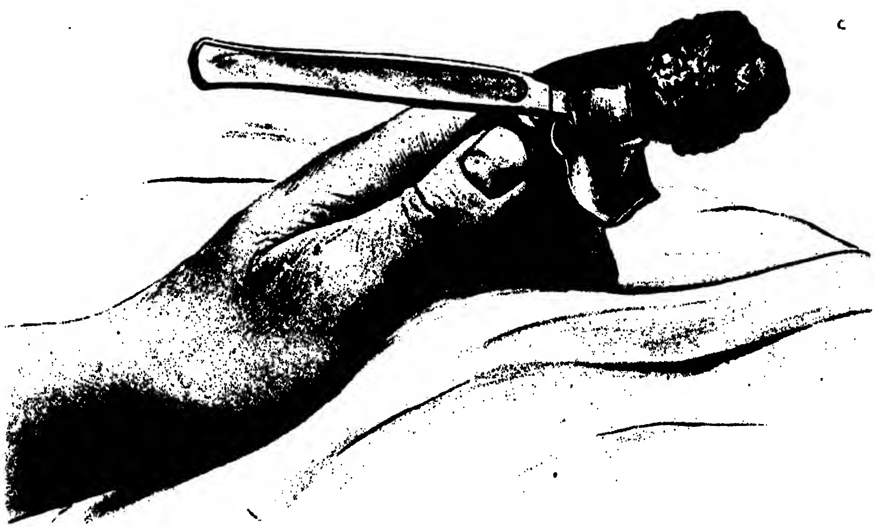


FIG. 336. AMPUTATION OF THE PENIS. *Transfixing the penis.*

choice lies with the surgeon, but if the situation of the disease necessitates a dorsal flap, this may be made use of without hesitation.

It is usual to control the circulation in the organ by encircling its base with a piece of rubber tubing drawn sufficiently tight. This is an unimportant detail, since firm compression of the root of the penis by the assistant's fingers is quite sufficient if the surgeon operates reasonably quickly.

The first point in the operation itself is to prevent the foul cancerous mass contaminating either the fingers of the surgeon or the skin of the stump, and for this purpose nothing is better than to sear the surface of the growth thoroughly with the actual cautery; after this, the glans is wrapped in several layers of gauze soaked in 1 in 20 carbolic lotion, with a piece of sterilized jaconet outside. This is fixed round the end of the penis beyond the proposed line of amputation by tying it tightly

with a stout ligature. No contamination of the wound can then occur during the later stages of the operation.

After the parts have been shaved, and the skin over the groins has been purified, an assistant seizes the end of the penis and holds the organ vertical whilst the surgeon marks out a U-shaped flap from its under surface by means of a vertical incision along the middle of each lateral aspect of the organ, united by a transverse cut across the under surface. The corners of the flap thus marked out should be rounded off, and its base should be opposite the proposed point of section

FIG. 337. AMPUTATION OF THE PENIS. *The stump.*

of the corpora cavernosa. A few touches with a sharp knife suffice to raise the flap from the underlying parts, and it is then folded back upon itself, whilst the surgeon, feeling for the line of demarcation between the corpus spongiosum below and the corpora cavernosa above, transfixes the penis with a narrow-bladed bistoury between these two structures on a level with the base of the flap already raised; the blade of the knife is kept parallel to the under surface of the corpora cavernosa. The edge of the knife is then turned towards the corpora cavernosa, and these structures are severed completely at right angles to the long axis of the organ by a rapid sawing movement (see Fig. 336). The corpus spongiosum is then dissected down towards the tip of the penis for about ½ inch and cut across; this leaves the stump with the corpus spongiosum cut longer than the corpora cavernosa (see Fig. 337).

The bleeding proceeds chiefly from the dorsal artery, but occasionally

the arteries of the septum bleed freely; they are easily arrested by torsion or ligature, however. Before the flap is sutured in position it must be perforated to allow the urethra to pass through it; this is done by thrusting the knife through the flap at a suitable spot, and the urethra, divested of as much of the corpus spongiosum as possible, is pulled out through it (see Fig. 338). A few fine horsehair sutures secure the flap, and, in order to prevent circular contraction of the newly formed meatus, the urethra is split up with scissors on each side, and the superior and inferior lips thus formed are sutured to the opening in the skin through which it emerges.

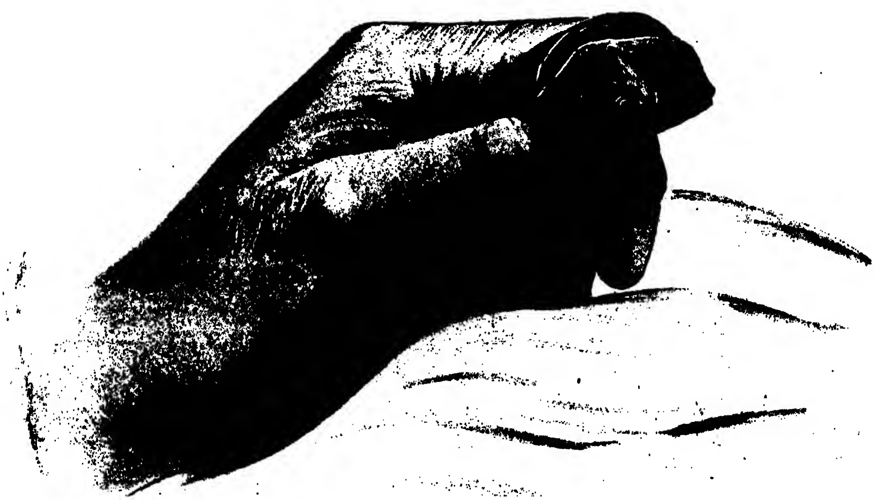


FIG. 338. AMPUTATION OF THE PENIS. *The flap in position.*

No dressing is needed, if the bedclothes be kept from contact with the parts by means of a cradle; micturition will take place normally, and the parts should be bathed with warm boric lotion after the act. The wound should heal by first intention, but careful watch must be kept to see that no contraction of the newly formed meatus occurs; any tendency to this can be met by passing twice weekly a conical metal bougie 2½ inches long, and graduated in size from Nos. 8 to 11 English.

Removal of the inguinal glands. This should be done on both sides and as thoroughly as in the corresponding operation for cancer of the breast. A crescentic incision with its convexity downwards is commenced just below the external abdominal ring, carried outwards across the groin and up again to Poupart's ligament within an inch of

the anterior superior iliac spine; the lowest point of the incision should be about 3 inches below Poupart's ligament. The flap thus marked out is raised well up to Poupart's ligament; it is held back by an assistant while the glands are dissected out as far as possible in one mass. It will generally be advisable to tie and divide the internal saphenous vein just before it joins the femoral; the dissection should be carried up well inside the saphenous opening, and the gland occupying the crural canal should be removed also. Every effort should be made to remove the glands in one mass, and if the one in the crural canal be adherent it is better to abandon the operation, as this implies such widespread infection that little good is likely to result.

When the glands have been removed, the flap is replaced and sutured in position, with a drainage tube at the most dependent spot for the first twenty-four or forty-eight hours. There is often free oozing from the various veins joining the internal saphenous.

Difficulties and dangers. The operation is simple and presents few difficulties; the chief is hæmorrhage, but even though no tourniquet be used, this is not of any importance if the operator be quick in his manipulations. The author prefers to use no tourniquet, as the compression exercised by india-rubber tubing drawn sufficiently tight to stop the circulation is apt to give rise to severe bruising of the erectile tissue, ending in troublesome chordee. If the surgeon knows where to look for the vessels, *viz.* on the dorsum in the middle line and on either side of the septum about half-way down, the bleeding points can be picked up easily and twisted or tied. It is important to stop all bleeding before suturing the flap, as otherwise blood may be extravasated beneath it and prevent union. Some surgeons pass a bougie in order to define the urethra prior to the transfixion of the penis; this is not only unnecessary but objectionable, for the surgeon can always make out the whereabouts of the corpus spongiosum by touch, and passing a metal instrument down the urethra is very likely to carry infective material into the neighbourhood of the wound.

COMPLETE AMPUTATION OF THE PENIS

Indications. This operation is generally done for recurrent epithelioma of the penis. It is rare for a patient to neglect to seek advice for epithelioma before the disease has spread far. When, however, the mischief extends much more than an inch backwards from the corona, and certainly when it extends as far back as the penoscrotal junction, it will be advisable to remove the organ completely in order to make sure of getting beyond the disease. This operation,

like the previous one, should always be combined with excision of the inguinal glands on both sides; it has the advantage that not only are the primary growth and the inguinal glands removed, but the whole of the cutaneous lymphatic tract is taken away also.

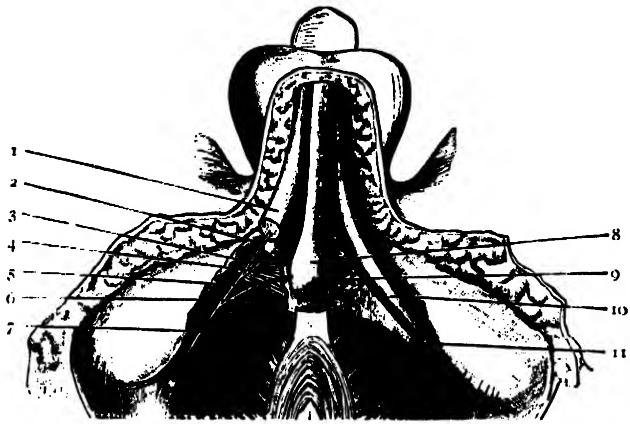


FIG. 339. THE PARTS CONCERNED IN AMPUTATION OF THE PENIS. *Superficial layer.* 1, Corpus cavernosum; 7, Pudic nerve with branches to the corpus cavernosum, 2, the dorsum of the penis, 3, and the bulb, 5; 4, Compressor urethræ muscle; 6, Triangular ligament (deep layer); 8, Bulb; 9, Triangular ligament (superficial layer); 10, Crus penis; 11, Levator ani muscle.

FIG. 340. THE PARTS CONCERNED IN AMPUTATION OF THE PENIS. *Deep layer.* 1, Perineal branch of the small sciatic nerve; 2, Anterior superficial perineal nerve; 3, Bulbo-cavernosus muscle; 4, Erector penis (ischio-cavernosus) muscle; 5, Transversus perinei muscle; 6, Tuber ischii.

The operation here described for complete amputation of the penis follows in the main the lines laid down by Mr. Pearce Gould (*Lancet*, 1882, vol. i, p. 821).

Operation. The parts are shaved and thoroughly purified from the hypogastric to the anal region, including also the upper third of each thigh; the compress put on overnight for purification of the front of the abdomen and thighs may remain undisturbed during the first part of the operation.

The patient is put in the lithotomy position and an incision is carried down in the middle line from the peno-scrotal junction to the mid-point of the perineum, and deepened until the corpus spongiosum is reached and defined. This should then be cut across well behind the growth (which

FIG. 341. COMPLETE REMOVAL OF THE PENIS. *First stage.* The scrotum has been split and the bulb exposed.

should be prevented from contaminating the wound by the measures described on p. 628), and along the urethra is passed a steel sound which renders it prominent and enables the surgeon to dissect it away from the corpora cavernosa with a few touches of the knife as far as the triangular ligament; it is left hanging in the wound for future use. The surgeon now turns to the crura, which are traced downwards and backwards from the main body of the penis to their attachments to the rami of the pubes. Each crus is carefully and completely dissected off the bone throughout its full extent. The best instruments with which to

do this are stout blunt-pointed scissors and a Farabeuf's rugine; a good deal of oozing generally accompanies this part of the operation.

When the crura have been detached completely, the root of the penis is encircled by an elliptical incision which is carried up to the symphysis. The suspensory ligament is found and divided, and the penis is dissected downwards. The dorsal vessels are secured as they pierce the triangular ligament, and the whole organ can then be removed. The operation is

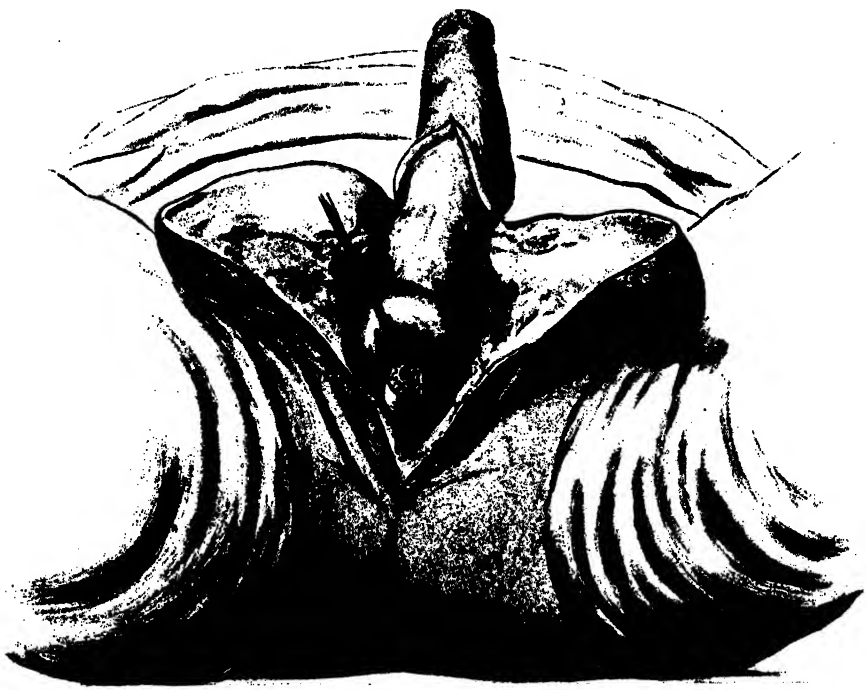


FIG. 342. COMPLETE REMOVAL OF THE PENIS. *Second stage.* The urethra has been cut across just beyond the bulb.

completed by removing the inguinal glands on each side, using for the purpose the incision described on p. 630. It is an advantage, however, in this case to make the incision so that the cutaneous lymphatic area between the penis and the inguinal glands is removed by it.

At the end of the operation the divided urethra is brought down into the perineum, cut off to an appropriate length, and stitched to the lips of the wound about an inch in front of the anus. The remainder of the incision is united throughout (see Fig. 344). It is best to insert a small drainage tube at the base of the scrotum for forty-eight hours; the latter should be enveloped in large dressings, but the region of the urethral orifice should be left free.

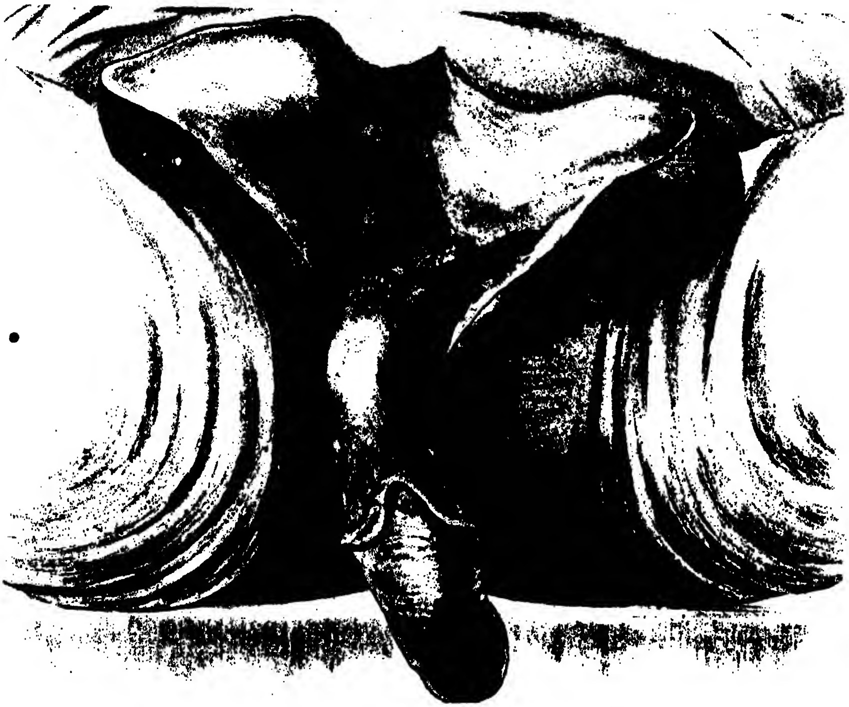


FIG. 343. COMPLETE REMOVAL OF THE PENIS. *Third stage.* The crura have been detached, the dorsal vessels of the penis secured and divided, along with the suspensory ligament of the penis.

FIG. 344. COMPLETE REMOVAL OF THE PENIS. *Final stage.* The wound has been sutured. The orifice of the urethra is seen in the perineum.

CHAPTER XXII

OPERATIONS UPON THE SCROTUM AND CORD

THE RADICAL CURE OF HYDROCELE

Indications. (i) In all hydroceles in which a radical cure by other methods, such as the injection of iodine or carbolic acid, has been attempted unsuccessfully.

(ii) In all cases in which the sac-wall is much thickened, or in which the hydrocele is not translucent. Here the milder injection methods are almost sure to fail, and it is better to perform the excision operation without having recourse to them.

(iii) In all cases in which the patient is very anxious to make sure of a radical cure without delay. By adopting the method described below, a radical cure at the end of a few days can be promised with reasonable certainty.

Only two methods of operating call for special remark: they are excision of the parietal layer of the tunica vaginalis, and eversion of the tunica vaginalis. Of these the former, which aims at removing all the removable part of the tunica vaginalis which is the primary seat of the trouble, is obviously the sounder in principle, whilst it is undoubtedly the more satisfactory in practice. Eversion of the tunica vaginalis, as its name implies, aims at turning the tunica vaginalis inside out and fastening it in that position by a few sutures. This has the objection that, whilst it entails nearly as extensive a cutting operation as the other, it does nothing to diminish the secreting area. Since recurrences have been known after imperfectly performed excisions of the tunica vaginalis, it follows that the eversion method is likely to be inferior to the other, while cases have occurred in which the sutures used to retain the tunica vaginalis in its everted position have given rise to troublesome constriction of the cord: this method, therefore, will not be described.

Operation. The parts are shaved and thoroughly purified, and the penis is wrapped in a sterilized cloth and kept out of the way. The skin of the scrotum is made as tense as possible, as in puncturing

a hydrocele, and a vertical incision is made over the upper and front part of the scrotum just of sufficient length to enable the enlarged scrotal contents to pass through it in its stretched condition. The anterior surface of the hydrocele is then carefully cut down upon, the object being to divide the successive coverings of the testis evenly and equally throughout the length of the wound, without opening the cavity of the tunica vaginalis itself; this demands a sharp knife and a light touch, but it facilitates the steps of the operation greatly, as premature opening of the hydrocele leads to collapse of its walls and to greater difficulty in identifying and removing the parietal layer. As the layers are divided, the hydrocele with the testicle are gradually squeezed out of the wound and are received in a sterilized cloth and thus shut off from contact with the scrotum below and behind it. When the surgeon recognizes that he has cut down to the tunica vaginalis itself, all the coverings superficial to it are stripped off with a flat blunt dissector as far back around the hydrocele as possible, the object being to clear the tumour right up to the reflection of the tunica vaginalis on to the testicle, while the sac is still distended with fluid and thus easily definable.

The tunica vaginalis is now opened up and the fluid allowed to escape, the margins of the incision are held aside with catch-forceps, and the entire parietal layer of the tunica vaginalis is clipped off right up to its reflection on to the epididymis; care is required to define this line exactly, especially at the globus minor. As a rule there is little bleeding during the division of the coverings of the hydrocele; there is, however, fairly free oozing from the cut surface of the reflected tunica vaginalis, and this must be arrested carefully. A number of ligatures will be required, and, if necessary, adrenalin may be applied to the oozing surface. It is also useful to swab over the visceral layer of the tunica vaginalis with undiluted carbolic acid; the author always adopts this as an additional precaution against recurrence.

The testicle, which now shows the appearance depicted in Fig. 345, is returned inside the scrotum, the wound in which has so contracted that it is only just large enough to admit it. A fine drainage tube should always be inserted, as otherwise a very unpleasant scrotal hæmatoma may result and may lead the patient to think that his hydrocele has not been cured. The wound should be secured by two or three fine horse-hair or silkworm-gut sutures, between which Michel's metal clips may be inserted. A continuous suture should not be employed, as the scrotum contracts so as to render proper approximation with a continuous stitch uncertain.

The drainage tube should be secured in place by a suture or a safety-

pin, as otherwise it may slip into the scrotum and be lost. A large mass of dressing should be applied and should be bandaged on tightly so as to exercise a certain amount of pressure upon the scrotal tissues.

The drainage tube may be removed at the end of twenty-four hours, when it is a good plan to apply a collodion dressing, which keeps the scrotum well contracted, so that there is less fear of hæmorrhage occurring into it. The scrotum should be supported on a pillow, and the patient should remain in bed for at least five days after the operation; he may then get up, wearing a suspensory bandage, but should keep quiet for a few days longer.

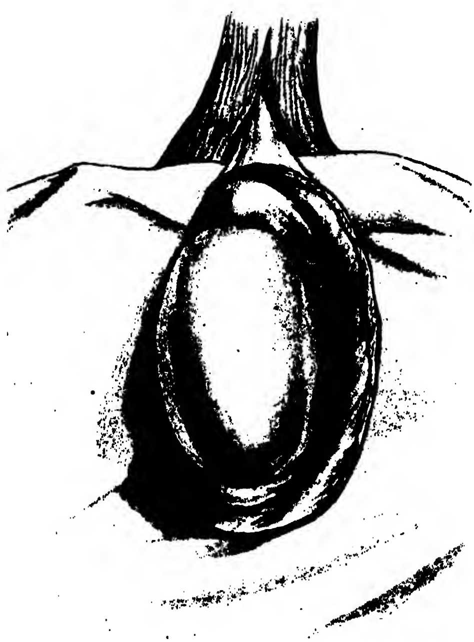


FIG. 345. EXCISION OF THE TUNICA VAGINALIS FOR THE RADICAL CURE OF HYDROCELE.

Complications. The chief complication to be feared is the occurrence of free venous oozing into and between the various scrotal coverings, which causes a large diffuse hæmatoma; the best way of avoiding this unpleasant and fairly frequent complication is to follow strictly the steps of the operation given above, cutting straight down to the tunica vaginalis before any attempt is made to strip the soft parts off, and then to strip the coverings off the tunica vaginalis *en masse* before the latter is opened. This avoids tearing up the coverings unduly, which is a frequent cause of a diffuse hæmatoma. It is also essential to stop all bleeding before the wound is closed, and great care should always be devoted to this; finally, the introduction of a drainage tube is essential if the surgeon is to make sure of avoiding a hæmatoma.

Results. The results of the operation may be said to be eminently satisfactory; the author has never known a case of recurrence in his own practice, nor has he ever met with a case in which a patient sought relief for recurrence after this operation had been performed by another

surgeon. Septic complications are extremely unlikely to occur, especially if undiluted carbolic acid be used as recommended above; healing is rapid, and the patient is generally well by the tenth day.

OPERATIONS FOR VARICOCELE

The radical cure for varicocele aims at the obliteration of as many of the branches of the pampiniform plexus as possible, leaving only a sufficient blood-supply to the testicle to ensure its proper nutrition. Ligature and excision of the veins is the only operation that needs consideration here.

Indications. (i) *For all persons suffering from varicocele who desire to enter the public services.* To these the presence of varicocele is a bar, and the operation is therefore a necessary preliminary.

(ii) *In cases where there is a history of recurrent attacks of phlebitis and thrombosis* in a varicocele which otherwise does not give rise to many symptoms. It is essential here to remark that the operation should be done during a quiescent period, as otherwise a troublesome spreading thrombosis may occur at the seat of the ligature.

(iii) *In certain cases of sexual hypochondriasis associated with the presence of varicocele.* These cases need the most careful discrimination and the most cautious prognosis; but it occasionally happens that a patient suffering from a varicocele gets the most extravagant notions as to the serious and progressive nature of his complaint, and nothing will satisfy him but the removal of the diseased veins. It is true that these cases generally suffer from other neurotic affections either before or after the operation, which is by no means always advisable for all melancholic individuals who are the subject of a varicocele; it is only when the varicocele assumes undue importance in the patient's eyes that its removal will be called for.

(iv) *When the patient is about to proceed to a hot damp climate where he will be out of reach of surgery for a considerable time.* Here the operation may be a justifiable and useful prophylactic.

Operation. The operation is extremely simple and satisfactory if properly done, but mistakes may be made which may seriously interfere with the patient's progress, and may even endanger his life. The most rigid attention to asepsis is necessary throughout; the purification of the genital area should always be attended to most carefully, and it is a good plan to fasten the penis out of the field of operation by passing a suture through the prepuce and attaching it to the skin of the opposite thigh. The greatest care must be taken to see that the material with which the veins are ligatured is aseptic,

and any surgeon who has the least doubt as to the reliability of his catgut had better employ fine silk, which should be boiled for at least a quarter of an hour immediately before the operation. Another point of much importance is to avoid unnecessary hæmorrhage. The secret of success in this operation is to attack the veins high up, where they are not only converging to form a few main trunks, but are also lying in a defined tube of fat and fascia distinct from the vas; here they may be surrounded with a ligature without much risk of bleeding.

An incision 2 inches long is made with its centre over the lower edge of the external abdominal ring, which can always be identified, and through which the cord can be felt escaping; the incision should never be lower than this. The cord is recognized immediately the superficial fascia has been divided, and, after its superficial coverings have been carefully cut through by incisions parallel to its long axis, the whole cord is hooked out either with the finger or on an aneurysm needle. The bundle of veins is isolated from the vas, secured with two stout ligatures placed about an inch apart, and the intervening portion removed with scissors. The ligatures may be made to transfix the cord if this be very bulky, but when there is not much fat it is quite safe to encircle the veins in a single loop. There is little likelihood of the ligature slipping if care be taken to divide the vessels some little distance beyond it. The vas always retains sufficient blood-supply if the normal line of separation between the veins and the vas be followed and the latter structure be not dissected off too cleanly.

The testicle now hangs supported only by the vas, and to prevent too great a dragging on this, it is the general practice to leave one end of each ligature long and to tie these loosely together; or a suture may be passed through the structures of the cord beyond each ligature and fastened. All bleeding is arrested and the wound is sewn up with a few horsehair sutures. No drainage tube is necessary if care be taken to arrest the hæmorrhage, and if no tearing of the veins has taken place during the operation. Good firm pressure is applied over the wound by dressings kept in position by a spica bandage. The patient is usually in bed for about a fortnight.

OPERATIONS UPON THE VAS DEFERENS

VASECTOMY

This operation was at one time practised as a substitute for castration for the cure of enlarged prostate, but has now fallen so completely into disuse that it is unnecessary to describe it here; its place has been taken by enucleation of the prostate, which is more certain in its action and more favourable in its results.

VASORRHAPHY

Indications. (i) Immediate suture of the vas is necessary should that structure be divided in the course of an operation affecting the cord, such as a radical cure of hernia or varicocele. In the author's experience this accident is most likely to occur in the operation for radical cure of inguinal hernia in young children. In them the vas is very delicate, often runs a tortuous course, and has a very intimate connexion with the hernial sac; consequently it is liable to be divided when the sac is separated from the constituents of the cord. In an adult who is the subject of a recurrent inguinal hernia, it is often difficult to avoid damaging the vas during the second operation for radical cure, since the tissues of the cord are often densely matted together and the whereabouts of the vas may be a matter of uncertainty until it has been divided accidentally.

(ii) Rupture of the vas by an injury rarely occurs, and is very difficult to diagnose when it happens. A plastic operation, however, should be done with the object of restoring the continuity of the vas if the condition be recognized. The operation would still be called for if the diagnosis were only made some considerable time after the receipt of the injury.

The author has twice had to repair a vas deferens accidentally divided in the course of an operation for radical cure of hernia. The first case was in a young child, the second in an adult during a radical cure for recurrent hernia after a previous operation followed by profuse suppuration. Both operations were successful in the sense that accurate adaptation of the sutured ends was effected and that no atrophy of the testis had occurred two years after the operation; the functional condition of the organ, however, could not, of course, be ascertained.

In each case the method employed was the one described below, for the main idea of which the author is indebted to the account of a case recorded by W. J. and C. H. Mayo in the *Annals of Surgery*, 1895, vol. xxi, p. 35. Several other methods have been described and figured, but the vas is such a small structure, and its lumen is so minute, that those plastic operations based upon the splitting open of one end and the implantation of the other into it are attractive only in theory; in practice they are of little use.

Operation. The cut ends of the divided vas are sponged clean of blood and a fine, straight, round intestinal or common sewing-needle is introduced, eye first, down the lumen of one of its divided ends. It is immaterial which end is chosen, but the needle employed must be of such a size that it can just be passed down with fair ease, and that when

an inch of it is in the lumen of the vas it is a moderately tight fit. The point of the needle is now introduced into the lumen of the other end of the cut vas, and the latter is threaded over it (see Fig. 346, A). The point of the needle soon pierces the wall of the vas and is allowed to protrude from it, and then the two ends are pushed together until they meet; the lumen on each side of the division is thus in accurate apposition. It only now remains to secure the ends in place while they are on the needle (see Fig. 346, B). Four sutures of the finest catgut obtainable, threaded upon correspondingly small needles, are introduced at each of the four cardinal points. This secures the ends, but for greater safety it is well to wrap them round in the fibrous tissues of the cord as in a sort of splint, securing this with a fine catgut stitch.

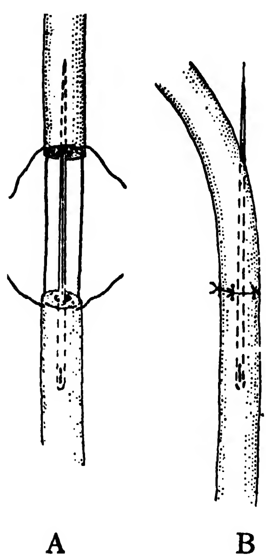


FIG. 346. ANASTOMOSIS OF THE VAS DEFERENS. A shows the needle *in situ* and the sutures introduced; B shows the operation completed, before withdrawal of the needle.

The vas is now laid down in place and the tissues are brought together over it with fine catgut sutures; the needle is then withdrawn from the vas by traction upon its point and the skin wound is stitched up without a drainage tube. W. J. and C. H. Mayo used catgut knotted at the points where the thread emerged from the vas, while Lydston (*Annals of Surgery*, vol. xliv) used silkworm-gut for threading through the lumen of the vas; the end of this was brought out either through the skin or into the wound, and it was left in position for about ten days and then removed by traction. In the brothers Mayo's case the catgut of course remained *in situ* until it was absorbed. The reason why the needle is preferred by the author is, that it is easier to thread down the lumen of the vas, it is stiffer to work upon, and so makes a most excellent temporary splint, while if it be left in position until the soft parts are sutured over the vas, there appears to be no necessity to maintain any foreign substance as a splint *in situ* any longer.

CHAPTER XXIII

OPERATIONS UPON THE TESTICLE

ORCHIDOPEXY

Indications. (i) In all cases of retained or misplaced testis in which the organ does not descend lower than the entrance of the scrotum.

In children it is common to find the testis suspended near the external abdominal ring, but capable of being pulled down to the bottom of the scrotum, only to slip up again directly the traction is relaxed. These cases should never be operated upon unless the condition be complicated with a hernia, at any rate before puberty; as the onset of puberty occurs, the organ becomes heavier, the cord stretches, and the testis tends to assume its normal position at the bottom of the scrotum. Should puberty pass without the testis assuming its normal position, however, operation is advisable.

(ii) In every case of misplaced or retained testis in which there is a coexisting inguinal hernia.

The age at which the operation should be done is of considerable importance. If possible it should be performed before the onset of puberty, since the testis ought to be in its normal position by the time it is assuming its virile characters. At the same time the child must be old enough to obey orders and to be quite clean in his habits, as the least sepsis is fatal to the success of the operation. On the whole, eight or nine is perhaps the best age. The operation may be done after the onset of puberty, but in that case more difficulty is experienced in bringing the testis down into position, there is more chance of want of development from deficient blood-supply afterwards, and there is considerably more discomfort occasioned by the after-treatment.

Choice of operation. There are three operations at the surgeon's disposal: *viz.*, complete removal or castration, permanent incarceration of the testis within the abdominal cavity, for which the fanciful name of 'orchido-cœlioplasty' has been coined, and true orchidopexy or suture of the testis into its normal position. Of these methods the author invariably chooses the last in every case in which it is possible, and he has not yet met with a case in which it is impossible. Castration was formerly practised under the erroneous impression that

retained testes were always functionally useless. The author long ago discovered the inaccuracy of this view when examining a retained testis removed in the course of a difficult radical cure of a hernia in a man of 55. The testicle contained large numbers of active spermatozoa and showed no other sign of abnormality than its small size. Since then there has been an opportunity of examining four other adult retained testes, and in all of them active spermatozoa were present. Castration is therefore clearly unjustifiable in this affection.

In 1892–3 the author, in five cases, made use of the method which is now termed orchido-cœlioplasty, and which he then believed to be original with him, *viz.* placing the testis inside the abdomen and closing the abdominal ring. The operation seemed a good one and the immediate results were promising, but luckily its weak points became apparent before enough cases had been operated upon to justify its publication. Two years after operation an adult patient contracted gonorrhœa, and the attack of acute peritonitis that accompanied the gonorrhœal epididymitis in the affected organ led to the decision that, should circumstances ever demand inclusion of the testis in the abdominal cavity again, division of the vas should accompany it. A second case—a schoolboy, aged 11—showed another weak point in the operation. About eleven months after the operation he was kicked in the abdomen, and an alarming attack of peritonitis followed, and a large localized swelling, which turned out to be a hæmatocele, ensued. In a case operated upon by a colleague, an acute hydrocele formed during a severe attack of bronchitis, and this gave rise to acute peritonitis.

This method, therefore, should be reserved for those cases in which true orchidopexy (*vide infra*) cannot be performed, and in doing it particular care must be taken to see that the testis is returned well inside the abdominal cavity and not only just inside the internal ring. In the latter situation it is not only very liable to injury, but it may act as a dilator in forcing the internal ring and producing a hernia. It also seems advisable to divide the vas in order to avoid the possibility of the spread of infection from the urethra. Division of the vas is not followed by atrophy of the testis if the vessels and nerves be left intact; it only entails loss of procreative power in the organ affected.

The third method, *viz.* orchidopexy, is the one that an increasingly large experience, both in children and adults, shows to be the best. It is true that it has had many objections urged against it. The chief of these are put forward by Mr. E. M. Corner (*Diseases of the Male Generative Organs*, The Oxford Medical Manuals, 1907, p. 88), and are as follows :—

After quoting 'a recent' (but in the author's experience quite inaccurate) estimate that perfect success followed the operation in 30%

of cases between the ages of 5 and 13 and only 10% at later periods of life, he states that the testicles thus sutured 'have not the necessary congenital capital to develop fully; they must always remain small'. While, owing to a slight uncertainty as to what 'congenital capital' may be, the first part of this statement must necessarily be a matter of opinion, the second is one of fact, and the author has seen many cases, some nearly twenty years after the operation, that disprove it. The second objection advanced is that 'the cord must be freed; a proceeding not without danger to the vessels, injury to which means non-development of the gland'. In a properly performed operation the vessels are certainly not interfered with to such an extent as to lead to non-development subsequently, and those who have had much experience in the wide removal of veins in varicocele operations will agree that in them the vascular supply of the testis may be quite as much interfered with as in cases of orchidopexy without any risk of non-development ensuing. In orchidopexy the testis often hangs from a slender stalk consisting of the vas and its vessels only, but in the author's experience this operation has never been followed either by sloughing or non-development.

The third objection is that the cord, which has been freed in order to draw the testicle down, must cicatrize, and will be likely to pull the gland upwards again. Exactly how this is to be effected it is difficult to discover. If it be inferred that, owing to the formation of granulation tissue, the cord will contract in the vertical direction only, the important fact is overlooked that cicatrization will occur all around the cord, and this will cause it to form adhesions right down to the bottom of the scrotum, which should effectually prevent retraction. The fourth objection is that vessels not directly severed at the operation may be stretched so tightly as to impede the return of blood through them, and that, further, their walls may be so damaged as to lead to post-operative thrombosis. Whilst not denying the possibility of these accidents, the author would suggest that they are not altogether unconnected with sepsis, which is well known to have been a great foe to this operation in its early days. The same remark applies with still greater force to the fifth and last objection, which is that the sutured testicle is very prone to suffer some subacute or chronic orchitis 'as a result of the impeded vascular return'. This condition occurs after operations upon the testicle no doubt, but its cause is generally sepsis and not a mere mechanical one.

Against this very formidable array of objections may be placed the fact that the author has never seen a case of sloughing or atrophy of the testis in the many operations that he has performed in adults and

in children, and although the majority of cases have not been followed up sufficiently carefully to warrant any statistical statement of the results, yet the uniform success obtained in those that have been seen years after the operation lead him to recommend the operation to those who are sufficiently sure of their aseptic precautions to warrant them performing it.

Operation. A slightly oblique incision about 1 inch in length is made parallel with the long axis of the inguinal canal just over the external abdominal ring, and the structures covering the cord are exposed and the testis is identified. The coverings of the cord are divided by an incision parallel with that through the skin until the tunica vaginalis is reached and opened. In practically all cases this is continuous with the peritoneal cavity, and often contains a hernia. The testis is now lifted out of its bed, and it and the vas are freed as far up as the internal abdominal ring. The testicle is pulled upon in order to see how far down it can be pulled; this will put upon the stretch a portion of the processus vaginalis, which must be divided by careful snips of the scissors, thus allowing the vas to straighten. The latter structure is generally long enough to allow the testicle to reach to the bottom of the scrotum, but it runs a tortuous course, the real factor impeding the descent of the testis being the shortened processus vaginalis and the tube of fascia containing the pampiniform plexus, which will need to be divided to the extent requisite to allow the testicle to be brought down; it is often necessary to divide all the vessels except the artery of the vas and its companion veins, and the testis has therefore a very narrow pedicle. When the testicle has been brought down as low as this manœuvre will permit, it sometimes happens that it is necessary to separate the vas from the back of the epididymis and thus to invert the testis, making the globus major the lowest portion of the organ; this, however, is not usually necessary.

The next step is to make a bed for the testis in the corresponding undeveloped half of the scrotum. This may be done by thrusting the index-finger through from the wound down into the bottom of the scrotum. This gives room enough for the testis to be inserted, but it will not remain in position there unless some method of tethering it in position be employed. After trying various methods, the author has found none so convenient or so simple as the wire frame introduced by Sir Watson Cheyne (see Fig. 347). In order to secure the testis to the transverse bar of this apparatus a medium-sized silk thread is passed through the tissues at the bottom of the organ, taking care not to transfix the epididymis. The two ends of this suture are then threaded together into the eye of a large straight needle, which is passed down along the finger introduced into the newly-made cavity in the scrotum and is made

to emerge from the bottom of the scrotum at its lowest limit. The needle is then unthreaded and the two ends of the silk thread are pulled upon and thus made to draw the testicle down as far as it will come. The ends of the thread are now passed round the transverse bar of the wire frame and tied in a bow. When replacing the testicle in the scrotum before making traction upon the ligature, it is important to see that the vas is not twisted, as otherwise gangrene of the testis may occur.

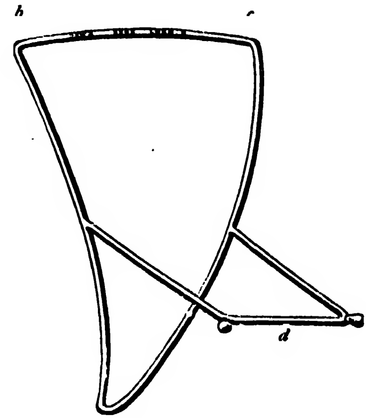


FIG. 347. CHEYNE'S TESTICLE FRAME. The suture is fastened to the transverse bar *d*. Sterilized tapes are fastened to the points *a*, *b*, and *c* to keep the frame in position; *a* rests on the mid-point of the perineum, *b* and *c* on either side of the mid-line in the hypogastric region.

When the testicle has thus been secured, every oozing point should be tied with fine catgut, and the skin wound closed without a drainage tube. The ordinary dressings are applied to the affected side of the scrotum and the point through which the ligature emerges from it.

After-treatment. The patient should stay in bed for a fortnight, and careful watch is kept upon the ligature to see that it is always tight. It is a good plan to increase the tension slightly every second day by untying the knot and refastening it. Sometimes the traction causes the silk thread to cut its way out about the tenth day: if this does not occur, it may be pulled through by traction upon one end.

If there be a hernia, the appropriate steps for closure of the inguinal canal should be taken before the skin wound is closed.

EPIDIDYMECTOMY

Indications. Epididymectomy, or excision of the epididymis, is only called for in certain cases of tuberculous disease of the testis. The merits of this operation and its indications have been much disputed, and even at the present day its exact position cannot be said to be defined. The plan of performing early castration for unilateral tuberculous disease of the testis is rejected by many surgeons in favour of the more logical one of excising the tuberculous area in the affected organ, mainly on the ground that it is thereby possible to remove the tuberculous disease radically without any risk of destroying the internal secretion of the

testis; a matter of importance should the opposite testicle eventually become destroyed. More recently still, however, there is a tendency to dispense with even so limited an operation as this, and to employ curettage of the affected area combined with open-air treatment and the injection of tuberculin. A review of personal experience and a study of the literature on the subject indicate the following as the principal conditions for which the operation may be required :—

(i) All cases of tuberculous disease attacking the epididymis of the remaining testis after removal of its fellow. Castration is out of the question here, since the patient would be deprived thereby of the secretion of his remaining testis. The only alternative to epididymectomy is incision and scraping combined with treatment by tuberculin.

(ii) When there is advanced tuberculous disease either in both testes or in the survivor of two, the operation may be performed in combination with scraping or excision of tuberculous foci from the body of the testis. In these cases the results are not very satisfactory, but the operation is to be preferred to castration, which entails the loss of the internal secretion of the testis.

(iii) In early cases of unilateral or bilateral disease strictly limited to the epididymis, where there is a prospect of removing the disease completely without sacrificing the testicle.

In both of these last two groups of cases the great difficulty is to determine whether the body of the testis be affected or not, and it is probable that some of the unsatisfactory results recorded after the operation are due to the fact that the epididymis alone has been removed when the body of the testis has been affected simultaneously. Since a proper selection of cases is essential for successful treatment, and since it is impossible to tell by palpation whether the body of the testis be affected or not, the author has been in the habit for the last two years of incising the body of the testis freely in order to ascertain this point. He was led to it partly by the considerations just mentioned, and partly by noting that, in cases of wounds of the body of the testis in which the organ is split completely open, there is no apparent bad after-result after suture of the cut edges of the tunica albuginea. The practice has been to incise the tunica albuginea freely, so as to split open the body of the testis much in the same way as the kidney is explored; this enables the operator to see at once whether there be any affection of the body of the testis; if so, appropriate measures can be adopted. Under these conditions epididymectomy becomes as sound and radical an operation as castration itself, while it is free from the serious results that may follow the latter operation. Mr. R. J. Godlee, in his Bradshaw Lecture on 'Tuberculosis of the Genito-Urinary Organs' (*Brit. Med.*

Journ., 1907, vol. ii, p. 1702), says: 'I have given up removing every tuberculous testicle, however quiescent, if no sign of the presence of tubercle could be found elsewhere, because it has so often led to disappointment, the patient returning before long with the opposite testicle affected. I do not hesitate to remove one testicle which is completely disorganized, both body and epididymis, if it is causing much pain or inconvenience, and under such circumstances would take away as much of the vas as can easily be got at; but in most cases removal of the epididymis appears to be the better practice and equally efficacious. Thorough curetting often gives excellent results.'

Numerous statistics have been prepared to show the relative frequency with which tuberculous disease occurs in both testicles, but these are very conflicting, and it is certain that the disease may recur in the opposite testicle in spite of early castration. It is therefore of little value to quote statistics as to the relative frequency of recurrence after epididymectomy and after castration. There is probably not much difference in this respect between the two operations. A more important point is the frequency with which the body of the testis is implicated by the time that the mischief in the epididymis is sufficiently pronounced to be detected. The best series of figures is given by Réclus, who found by post-mortem examination that both portions of the testis were involved in 48 out of 68 cases. This high proportion may surprise those who have been in the habit of merely palpating these cases and finding the lesion apparently limited to the epididymis in the large majority of cases. The author confesses, however, that since he has had the opportunity of obtaining more precise knowledge by laying open the body of the testis, his opinion upon the matter is much more in accord with Réclus' statistics.

Operation. An incision from 2 to 3 inches long is made over the front of the scrotum parallel with the long axis of the testicle. If any portion of the skin be adherent, or if there be a sinus present, the affected area is enclosed in two elliptical incisions and removed. The tunica vaginalis is opened and the testicle is exposed. Removal of the epididymis is usually easy when there is no tuberculosis of the body also; the important point is to preserve the blood-supply of the testis derived from the internal branch of the spermatic artery, which reaches the body of the testis in the angle between it and the epididymis at the upper part of its inner aspect. The reflection of the tunica vaginalis binding the globus minor to the body of the testis is divided on each side with a knife or scissors, and the epididymis is peeled up from the back of the body of the testis until the globus major is reached, when the vas deferens is divided on a level with the upper border of the

testicle, care being taken to free it entirely from the vessels before this is done. The globus major is peeled off the body of the testis as completely as possible, after dividing the tunica vaginalis on each side; its actual connexion with the testis is ligatured and the epididymis is then cut away completely.

The body of the testis is now incised vertically along its posterior aspect; the incision need not extend more than a third of the distance through the organ unless tuberculous deposits be encountered. Incision of the tunica albuginea at once displays any tuberculous infection present, and the affected area can be clipped out cleanly with fine sharp-pointed scissors.

The edges of the divided tunica albuginea are brought together with a few fine catgut sutures, all bleeding points are ligatured, and a small drainage tube is inserted down to the bottom of the scrotum, the wound in which is secured by interrupted silkworm-gut or Michel's metal sutures. The drainage tube is removed in the course of twenty-four hours.

CASTRATION

This is an operation which should not be undertaken lightly. There are two distinct ill results produced by the removal of a testicle: one is the loss of procreative power, the other the loss of the internal secretion of the testis with its important psychological sequelæ. Neither of these results is serious provided that only one testicle be removed; the seriousness of the case lies in the fact that the other organ may become destroyed subsequently.

Indications. (i) *For new growths of the testis.* Castration is the best treatment for this condition, whether the growth be innocent or malignant; in the latter case the operation should be undertaken immediately the diagnosis is made, since these growths are very malignant, and all practical surgeons realize how gloomy the prognosis is in these cases. The only hope is in early operation, and therefore an immediate exploratory incision should be practised if there be the least doubt as to the nature of any tumour of the testis.

(ii) *For certain cases of tuberculosis of the testis.* The cases requiring castration demand careful discrimination. It is generally admitted that it is legitimate to remove a tuberculous testicle that is completely disorganized, and is the cause of pain or annoyance to the patient, provided that there be on the opposite side sufficient healthy testicular structure to maintain the internal secretion of the organ; for instance, it would be unjustifiable to remove a testicle, however disorganized, if it were the sole remaining one. The other condition for which castration

was at one time widely recommended, *viz.* early tuberculous disease limited to one testicle, has been discussed in connexion with epididymectomy (see p. 648), and it would seem that the latter operation, if properly carried out, is on the whole the preferable procedure in these cases.

(iii) The operation has been occasionally performed for *misplaced testis*: it should, however, only be resorted to when orchidopexy is impossible, the patient is advanced in years, and the testis is much atrophied.

(iv) Castration has been performed in order to effect a sound *radical cure of an inguinal hernia.* Such an extreme measure can, however, hardly ever be called for nowadays. Should it be impossible to avoid wounding the vas, the testis should still be left *in situ*; should the organ be misplaced, as a result of a previous attempt at a radical cure, it would appear better to free it and place it in the abdomen after dividing the vas so as to prevent the possibility of infection along it (see p. 644). This preserves the internal secretion of the testis, whilst it enables the abdominal ring to be closed entirely. At one time, when recurrence of hernia after a radical cure was common, an adherent testis was one of the chief obstacles to a successful second operation.

(v) Castration was largely practised at one time for the cure of *enlarged prostate*; it has, however, now given place to enucleation, which is more certain in its results and safer in its action. As double castration was necessary to produce any marked effect upon the prostate, the psychological results were formidable, and many deaths occurred as a result of it.

(vi) Castration has been performed for *syphilis*, but generally under a misapprehension as to the nature of the case; there is no necessity to perform the operation for the cure of syphilitic testis. For cases of injury castration is practically never required; the parts should be cleansed and the wound in the tunica albuginea closed by suture. It is very important to retain the internal secretion of the testis, even though the vas be divided. Castration has also been performed for old hæmatocele of the tunica vaginalis. There is, however, no reason why this drastic operation should be performed for such a condition; incision and drainage, combined with removal of the lining membrane of the sac, should be quite sufficient to effect a cure.

Operation. A free incision is made from just above the external abdominal ring down to the bottom of the scrotum. Should there be any part of the scrotum adherent to the testis, this should be included in elliptical incisions and removed. The incision is deepened down to the tunica vaginalis, but the latter cavity should never be opened, as infective material may be contained in it and may contaminate the

wound. The finger is passed round the tissues of the cord and, working downwards, frees the testicle and its ensheathing tunica vaginalis from the scrotal tissues. The whole organ is then drawn outside the wound and can be removed after ligature and division of the cord; this should be done in two parts, the vessels being taken up in one ligature, whilst the vas is secured in another. This latter structure should be isolated up to the abdominal cavity in all cases before it is tied and cut across. In cases of tuberculous disease the external oblique aponeurosis should be slit up so as to expose the internal ring fully, and the peritoneum should be stripped off the vas as far into the abdomen as possible before the former is ligatured and divided. In cases of malignant disease it is well to isolate all the structures of the cord as far up as possible before they are ligatured and divided; the vessels are followed up towards the loin and tied as high up as possible, while the vas is traced as near to the base of the bladder as the operator can reach and divided there. The internal abdominal ring may be slit up, if necessary to facilitate this step of the operation.

The surgeon may occasionally desire to make an exploratory incision into the testicle to ascertain whether a given swelling be malignant or not before he removes it. In this case no incision should be made into the testis until it and its tunica vaginalis has been delivered through the scrotum, as mentioned above, preparatory to ligature and division of the cord. It should then be wrapped in a sterilized towel interposed between it and the scrotal wound, and, after being surrounded with swabs on all sides to catch any fluid that may escape, the incision is made into it. Should this show the swelling to be malignant, a large pair of clamp-forceps is put upon the cord, and the testicle, still enveloped in the sterilized cloth, is removed by a single stroke of the knife below this, so that there is no risk of infecting the wound in the scrotum. The structures of the cord are then dealt with in the usual way by transfixion and ligature, as described above, after they have been isolated as far inside the abdomen as possible.

All bleeding points are ligatured and a medium-sized drainage tube is inserted at the bottom of the scrotum, and the inguinal canal is closed completely by a few catgut sutures. The drainage tube is removed in forty-eight hours.

SECTION V

OPERATIONS UPON THE THORAX AND ITS CONTENTS

PART I

OPERATIONS UPON THE BREAST

BY

HAROLD J. STILES, M.B., F.R.C.S. (Edin.)
Surgeon to Chalmers Hospital, Edinburgh, and to the Royal Hospital for Sick Children, Edinburgh

CHAPTER I

OPERATIONS UPON THE BREAST

OPERATIONS FOR CARCINOMA

Before describing the operative treatment of cancer of the mamma, it is necessary to refer shortly to the more important anatomical and pathological observations which have led to the development of the modern extensive operation.

SURGICAL ANATOMY

The breast tissue proper consists of a central part, the corpus mammæ, and of a peripheral portion made up of branching processes which become more and more subdivided as they extend into the paramammary fat, until finally they become continuous with the connective-tissue septa of the subcutaneous fatty tissue. The breasf, therefore, has no distinct capsule. In the young adult nullipara the corpus mammæ is compact, well defined, and contains but little intramammary fat, while the peripheral processes are relatively small. In the multipara the corpus mammæ contains more fat and the peripheral processes extend more widely into the paramammary fat.

The breast tissue has a much wider distribution than was generally supposed. The extent and arrangement of the parenchyma is well demonstrated by treating the breast with a 5 % solution of nitric acid. If slices of the fresh organ be placed in this solution for a few minutes and then washed under running water, the albumin of the epithelial cells of the parenchyma is coagulated, while the connective tissue is rendered transparent, homogeneous, and somewhat gelatinous. The ultimate lobules of the parenchyma now appear as little opaque, sago-like bodies, 1–2 millimetres in diameter, arranged in grape-like clusters around the terminations of the finer branches of the ducts.

The tooth-like processes which pass from the anterior surface of the corpus mammæ are attached to the skin by fibrous prolongations known as the suspensory ligaments of Cooper. The parenchyma is prolonged into these processes, and in spare women, with well-developed mammæ, it may reach almost to the skin.

Vertically the breast tissue extends from the second rib to the sixth costal cartilage at the angle where it begins to sweep upwards to the sternum; the horizontal diameter reaches from the edge of the sternum opposite the fourth costal cartilage to the fifth rib in the mid-axillary line. The inner hemisphere rests almost entirely on the pectoralis major; at its lowest part it overlies the upper part of the aponeurosis covering the

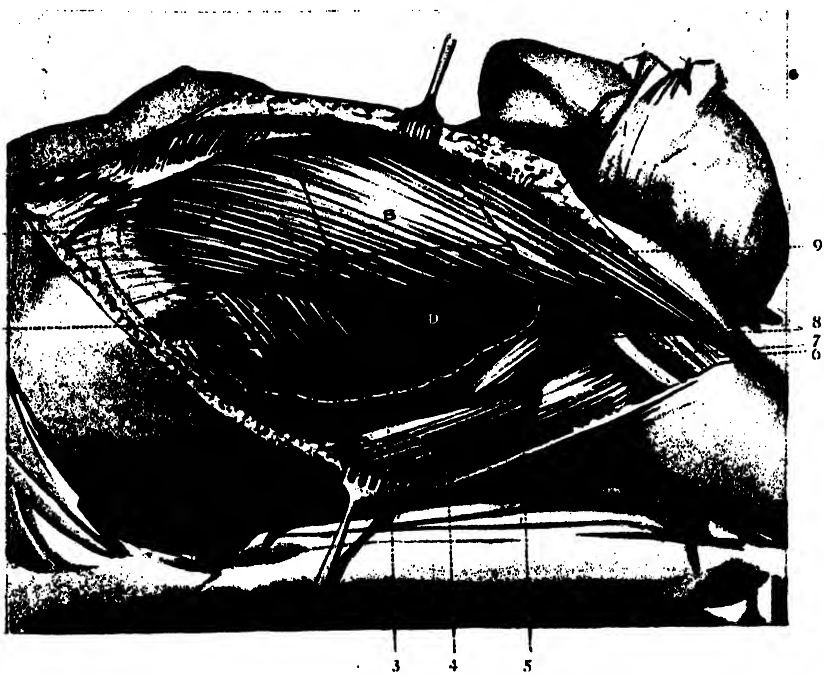


FIG. 348. DISSECTION OF THE FRONT OF THE CHEST AND AXILLA TO SHOW THE RELATION OF THE QUADRANTS OF THE BREAST TO THE SUBJACENT MUSCLES. 1, Left costal margin; 2, External oblique muscle; 3, Serratus magnus muscle; 4, Latissimus dorsi muscle; 5, Subscapularis muscle; 6, Short head of the biceps; 7, Coraco-brachialis muscle; 8, Sheath of the axillary vessels; 9, Pectoralis major muscle. The dotted line denotes the extent of the breast; the areas A, B, C, and D correspond to its four quadrants.

rectus and external oblique muscles. The upper half of the outer hemisphere rests upon the greater pectoral, on the edge of the lesser pectoral, and to a slight extent on the serratus magnus, upon which it extends upwards into the axilla as high as the third rib, where it comes into relation with the pectoral group of axillary lymphatic glands situated upon the inner wall of the axilla. The remainder of the outer hemisphere rests almost entirely upon the serratus, except the lowest part, which

overlaps the fleshy digitations of the external oblique arising from the fifth and sixth ribs. It follows, therefore, that about one-third of the whole mamma lies inferior and external to the axillary border of the pectoralis major. These relations have been dwelt upon in detail because the surgeon must cut beyond the limits here mentioned if he wishes to remove the whole of the breast tissue.

According to Heidenhain, in a breast which is the seat of an ordinary scirrhous cancer, there are present throughout the whole gland proliferative changes in the epithelium of the parenchyma and in the interacinous connective tissue which must be looked upon as precancerous, and which are sooner or later destined to develop into active malignant disease. While admitting the truth of the above statement in exceptional instances, the writer's pathological observations have led him to conclude that when cancer manifests itself in a portion of breast tissue which has been left behind as the result of an incomplete operation, the so-called recurrence generally originates in the same way as it does in the extrinsic tissues, *viz.* by the proliferation of cancer cells which have found their way into the lymphatics from the primary tumour. This question, although of great interest to the pathologist, is of less importance to the practical surgeon, since, in removing all the lymphatics of the breast, he must of necessity also remove all the parenchyma. The aim, therefore, of the operator should be to remove not only the breast tissue but also as much of the surrounding tissues as anatomical and pathological research has shown to be likely to contain the lymphatics along which the cancer cells have disseminated. Unfortunately, it is impossible in any given case to say definitely to what extent this dissemination may have taken place, and herein lies the difficulty and uncertainty in the operative treatment of the disease.

Lymphatics. The lymphatic system of the mamma consists of five sets of vessels which communicate freely with one another: (1) A cutaneous set including those of the nipple and areola. (2) The subareolar plexus of Sappey, which receives efferents from the skin as well as those intramammary lymphatics which accompany the main lactiferous ducts. (3) The intramammary lymphatics proper, which, after forming a network around the lobules, run for the most part along with the blood-vessels in the interlobular connective tissue. While some of the efferent intramammary lymphatics open, as above stated, into the subareolar plexus, the majority pierce the posterior surface of the gland to join the retromammary lymphatics. According to Poirier and Cunéo, some of the lymphatics which proceed from the upper hemisphere ascend over the clavicle to join the supraclavicular glands. (4) The lymphatics of the subcutaneous tissue superficial to the mamma form part of the general

subcutaneous lymphatic system of the chest and upper part of the abdomen; they anastomose on the one hand with the intramammary and deep fascial lymphatics, and on the other hand with the lymphatics of the skin, the channels of communication occupying for the most part the ligaments of Cooper. (5) The retromammary lymphatics occupy the loose retromammary cellular tissue and the deep fascia which covers the muscles subjacent to the mamma. They form the deep fascial lymphatic plexus which Heidenhain and the writer have shown plays such an important rôle in the local dissemination of the disease. The recent researches of Handley have still further demonstrated the importance of these lymphatics. According to this observer, when the lymphatic plexus of the deep fascia becomes involved the disease permeates it by a process of continuous growth which is centrifugal and practically equal in all directions. An important point to note, too, is that this plexus may become infected before the tumour has become adherent to the pectoral fascia, and is probably also the plane along which the disease spreads occasionally to the opposite axilla. 'Later on permeation spreads into the smaller muscular and cutaneous tributaries which drain vertically into the plexus and so infects the adjoining layers to a depth which reaches its maximum opposite the centre of the primary growth' (Handley). The small nodules which then occur at the junction of the skin and subcutaneous tissue are generally due to a superficial extension of the disease from the breast along the lymphatics contained in the ligaments of Cooper, or they represent 'accidental efflorescences of growth which have extended upwards from lymphatics of the deep fascia which have become permeated with cancer cells'. Handley has also shown that it is by the centrifugal permeation of the plexus which occupies the fascia covering the anterior sheath of the upper part of the recti and linea alba in the epigastric triangle that the disease generally reaches the peritoneal cavity and the liver. 'The cancerous permeation extends along the numerous finer anastomoses which, piercing the parietes, connect the lymphatic plexus of the deep fascia with the subendothelial lymphatic plexus of the pleura and peritoneum, and with the mediastinum and portal glands. . . . Unfortunately the microscopic growing edge is not clinically recognizable, and the surgeon cannot determine for each case as it comes before him how far the circle of fascial permeation has extended. If the case is a very early one, permeation may still be confined entirely within the limits of the breast. If it is moderately early, only a small area of the pectoral lymphatic plexus, an area perhaps not so large as the diameter of the breast, may have been invaded. But if the case, though still operable, is late, or if the cancerous epithelium is proliferating with more than

average rapidity, the permeated area of the deep fascial plexus may already have passed considerably beyond the margin of the breast.

'Since there are no satisfactory clinical means at present of fixing the limit of fascial permeation in a given case, the only safe rule is to remove a very wide circle of the deep fascia round the growth, and a smaller circular area of skin' (Handley).

The researches of Handley have led him to add to the radical operation the further routine step of removing the subcutaneous tissue and aponeurosis covering the recti over an area corresponding to the epigastric triangle.

With regard to the relative amount of skin and deep fascia which should be removed in the routine operation, Handley's researches confirm the original view of the writer that in the early stage of carcinoma of the breast, *i.e.* before the skin has become tacked down over the tumour, it is not necessary to remove an excessive amount of skin. It is important, however, to remove a wide area of subcutaneous tissue and deep fascia. Upon this point Handley writes as follows: 'The area of skin taken away in the operation should obviously be no larger than is necessary and no healthy skin should be removed. It has already been shown that cancer does not spread in the plane of the skin, but, nevertheless, free removal of skin is necessary, owing to the vertical extension to the skin after a time, and over a smaller area, of the growth which is spreading in the deep fascia. The necessary conditions can usually be fulfilled by the removal of a circular area of skin 4 to 5 inches in diameter with the growth at its centre. The very extensive ablation of skin carried out by some surgeons is based upon erroneous ideas of the pathology of dissemination and is not found practically to improve the results of the operation. . . . It is a fortunate circumstance that breast cancer spreads primarily in the parietes along the deep fascia and only secondarily involves the skin. For while removal of the skin has, in some hands, reached its furthest possible limits without any corresponding improvement in results, it is possible to remove the deep fascia over a wider area than is yet the usual custom. The removal of a maximal circular area of deep fascia centred upon the primary growth is a step absolutely essential to the completeness of the operation, except in very early cases. . . .

'It is only when the tumour is situated below the nipple that the latter should occupy the centre of the ablated skin. When the cancer is situated at the sternal margin of the breast the subcutaneous tissue and deep fascia must be excised for a considerable distance beyond the opposite edge of the sternum, while if it occupies its lower margin the fascia must be dissected off the rectus and external oblique, further down towards the

umbilicus. If, on the other hand, the growth be situated in the axilla, it will be necessary to excise the deep fascia as far as, or it may be even beyond, the cephalic vein as well as further back over the outer surface of the latissimus dorsi.'

The axillary lymphatic glands. The number of axillary lymphatic glands which may be met with in patients suffering from cancer of the mamma is often far in excess of that usually described by anatomists. This is accounted for by the fact that some of them are no larger than a pin's head, while others are frequently found to have undergone such marked adipose transformation that they are very liable to be mistaken for ordinary fat globules. Both these varieties are just as liable to become malignant as are the more typical glands. The early stage of glandular infection is, of course, microscopic, so that the absence of enlargement and induration of the glands is no proof of their freedom from malignancy.

While the pectoral group, which lies along the lower border of the pectoralis minor, is generally the first set to become infected, it must be remembered that the apical or subclavicular group may alone be affected. When the tumour is situated either at the lower or at the axillary border of the breast the subscapular group may be the first to become infected; when, on the other hand, the tumour involves the inner hemisphere this group generally escapes, or is infected only at a late stage of the disease.

From the operative point of view the subclavicular glands are by far the most important. Although diseased, it is often impossible to feel them by palpation through the floor of the axilla; they not infrequently give rise, however, to a feeling of deep-seated resistance or nodular induration when firm pressure is made over the infraclavicular triangular depression which corresponds to the intermuscular space between the clavicular origins of the pectoralis major and deltoid muscles. It is important that the operator should be familiar with the topographical relations of these glands. They lie in close relation to the superior thoracic artery, which ramifies in the cellular tissue and fascia covering the upper two intercostal spaces. When diseased they are liable to become adherent to the sheath of the highest part of the axillary vein. Above the glands are the clavicle and subclavius muscle, while immediately below them is the upper border of the pectoralis minor; in front of them we have, of course, the pectoralis major and the costo-coracoid (coraco-clavicular) membrane. It is in the region occupied by these glands that recurrence was so frequently met with when the operator contented himself with leaving the muscles and trusting to clearing the axilla from below.

The pectoral muscles. We are indebted to Halsted for adding to the

routine operation the removal of the pectoralis major muscle. This step is called for in the first place to obtain the necessary access for the removal of the subclavicular glands and fatty cellular tissue and fascia at the apex of the axilla, and in the second place, because Rotter has shown that the perforating branches of the internal mammary and of the superior thoracic arteries, after piercing the pectoralis major, pass through the retromammary tissue into the substance of the breast, and that these vessels are accompanied by paravascular lymphatics which are efferent for the breast. After piercing the pectoralis major these lymphatics occupy the retropectoral fascia and ascend between it and the pectoralis minor to open into the subclavicular glands. Rotter pointed out, too, that at an early stage of the disease and before the tumour has become adherent to the pectoral fascia, the cancer cells may be conveyed by these channels through the retromammary fat and pectoral muscle to small lymphatic glands situated in the fascia upon the posterior surface of the pectoralis major, as well as by the more generally recognized channels to the axillary glands. He found that dissemination had taken place by the former route in a third of the forty cancerous breasts he examined. These paravascular efferent lymphatics only pass through the sternal portion of the muscle, so that the clavicular fibres need not be removed in every case. In the cases in which the subclavicular glands are alone involved, it is no doubt along these retropectoral paravascular lymphatics that the infection travels.

The sternal portion of the pectoralis major and the pectoralis minor should therefore be removed as a matter of routine, (1) because either they or the glands and fascia behind and between them are liable to be infected, and (2) because it is only by their removal that the surgeon is able to thoroughly clear the subclavicular space. It is unfortunate that students in the dissecting-room are encouraged to dissect the axilla from below ; by approaching it from the front, after removing the sternal fibres of the pectoralis major and then the pectoralis minor, they would gain a much better conception of what is meant by a thorough clearance of the axilla, and they would have the additional advantage of being able to trace the blood-vessels and nerves from their origin to their distribution.

The serratus magnus. As a considerable part of the outer hemisphere of the breast lies upon this muscle, it is obviously important to remove the deep fascia covering it as well as that covering the upper digitations of the external oblique muscle of the abdomen. Unfortunately the fascia here is thin and tends to adhere to the muscles, especially where they interdigitate and where the lateral branches of the intercostal vessels and nerves pierce the fascia. If the tumour be adherent to the

fascia there should be no hesitation in removing along with it a wide area of the serratus, a portion of the adjacent external oblique, and, if necessary, a portion of the posterior thoracic nerve.

INDICATIONS FOR OPERATION

Except in the presence of special contra-indications depending for the most part on the general health of the patient, the radical operation should be performed whenever there is even a remote possibility of obtaining a permanent cure.

With regard to *palliative operations* in advanced cases no definite rules can be laid down. Each case must be judged on its own merits. Speaking generally, however, it may be said that palliative operations should be the exception rather than the rule, and they should not be undertaken unless there is every reason to believe that the patient's life will thereby be prolonged, or that the operation is likely to remove, or at any rate ameliorate, the mental or physical distress, such as is occasioned, for example, by the presence of a foul and painful ulcer.

The *operation is contra-indicated* (1) in the acute or inflammatory cancer, the so-called mastitis carcinomatosa of Volkmann; (2) in cancer *en cuirasse*; (3) when the tumour is associated with multiple lenticular disseminations in the skin surrounding it; (4) when the tumour is firmly fixed to the chest-wall; (5) in an elderly patient the subject of an old-standing atrophic or diffuse cicatrizing carcinoma; (6) when the glandular mischief in the axilla or in the neck is obviously so extensive as to preclude all possibility of a permanent cure, and when no palliative benefit is to be expected from a partial removal of the disease.

THE OPERATION

Preparation of the patient. The disinfection should not be confined merely to the pectoral and axillary regions, but should include also the neck, the shoulder, the upper arm, the abdomen down to the level of the umbilicus, and the back of the corresponding side of the chest as far round as the spinal column. A carbolic compress should not be applied over such an extensive skin area for some hours before the operation, on account of the readiness with which this drug is absorbed by the skin. If the skin be disinfected the night before the operation it should be covered simply with sterilized towels (or gauze) kept in position by a bandage. In nervous patients the writer is satisfied that it is not necessary to disinfect the skin the night before the operation, provided it be thoroughly done while the patient is under the anæsthetic. Repeated disinfection of the skin is the reverse of beneficial, as it only

serves to stir into activity the organisms in the deeper layers of the skin, and at the same time to diminish its resistance to infection.

For the preliminary cleansing of the skin the writer prefers a solution containing spirits of green soap and lysol. An advantage of this mixture is that all the time the skin is being mechanically cleansed with the soap, the lysol, which is a penetrating antiseptic, is also being well rubbed in. After washing off the above mixture with normal saline solution the skin is scrubbed with a large gauze swab freely soaked with Harrington's solution,[1] which is then removed either with sterile normal saline or with dry sterile gauze.

Dry sterilized sheets should be arranged so as to cover the whole of the operating table and the patient, except, of course, the immediate field of operation. A sterilized triangular handkerchief is applied to the head so as to cover up the hair completely, and a large moist gauze swab is placed across the neck. The upper extremity on the same side, enveloped in a sterilized sheet from the tips of the fingers to the middle of the upper arm, is held abducted to a little beyond a right angle by a nurse, who should wear a sterilized overall. The anæsthetist, who wears sterilized cotton gloves, should be screened off from the field of operation by a sterilized sheet, and, if he be an expert at his work, there is no need for the patient's face to be exposed to the view of the surgeon.

The anæsthetic. Except in patients who are very feeble and debilitated, or who are the subjects of cardiac mischief, the writer prefers to perform the operation under chloroform rather than under ether, as the bleeding is much less with the former drug, and less than half the number of artery forceps and ligatures are required. The operation can therefore be more quickly performed under chloroform, and a comparatively short chloroform anæsthesia, with little bleeding, produces no more shock than a more prolonged operation under ether. If ether be used it should be given by the open drop-method, a sixth to a quarter of a grain of morphine and a hundredth of a grain of atropine being given half an hour before the operation.

The operation is from beginning to end a strictly anatomical one, and it will be described step by step exactly as the writer is in the habit of performing it. It may be remarked, however, that as long as the operation is sufficiently radical, and founded on our present scientific knowledge of the paths of dissemination of the disease, the exact order of the steps in the technique is a matter of secondary importance.

The skin incision. In the development of the modern operation a good deal of attention has been devoted to the planning

[1] Commercial alcohol (94 %), 640 c.c.; hydrochloric acid, 60 c.c.; water, 300 c.c.; corrosive sublimate, 0·8 gramme.

of the skin incision. While it is better to err on the side of removing too much rather than too little skin, it is essential to bear in mind that whatever be the size and shape of the area of skin ablated, the part which overlies the tumour, and not necessarily the nipple, should occupy its centre. It is a mistake always to make the skin incision coequal with the outline of the mammary prominence; to do so in the case of a tumour placed at the circumference of the mamma would result in the sacrifice of an unnecessary amount of skin in one direction, and, what is still more important, in the removal of too little skin in the neighbourhood of the tumour. The tendency to depart too much from the wide elliptical incision with well-prolonged extremities has not always been in the direction of improvement.

The incision should be planned with the object of removing not only the breast and axillary contents, but also for the purpose of removing a still wider area of the circummammary fat and deep fascia. The objection to some of the incisions which have been recommended for the radical operation is that while they remove an unnecessary amount of skin in the average case, they do not allow of a sufficiently free removal of the subcutaneous tissue and deep fascia beyond the circumference of the breast.

The entire incision may be described as consisting of three parts, *viz.* (*a*) an ablation or delimiting portion, (*b*) an axillary portion, and (*c*) an epigastric portion.

(*a*) When the tumour is placed behind the areola, *the ablation incision* should take the form of a wide ellipse, or of an oval, placed with its long axis parallel to the lower border of the pectoralis major. The width of the ellipse will depend partly on the size and configuration of the mamma, and more especially on whether the skin is tacked down to the tumour, and if so, to what extent. If the skin be freely movable over the tumour, the ellipse need not necessarily include the whole of the mammary prominence, but if the skin be at all involved the ablation incision should be more or less circular, as it is wiser to err on the side of removing too much rather than too little skin, and all question as to the possibility of subsequent closure of the wound should be kept in the background.

When the tumour is placed at or near the circumference of the breast, the delimiting portion of the incision must be modified so as to bring the tumour as nearly as possible in the centre of the ablated area. This can easily be done by simply bowing out one side of the ellipse well beyond the tumour, or, what is often more convenient, by adding to the delimiting incision a more or less V-shaped incision so as to remove an additional triangular area of skin with its base formed either by the

upper or the lower segment of the main incision, depending on which hemisphere the tumour is situated in (see Fig. 349).

When the triangle is taken from the upper flap, the lower one, which is always the more redundant, can often be made to fill in the gap; if, however, the triangle be taken from the lower flap, the wound can sometimes be closed completely by suturing it in a T-shaped fashion. The various plastic methods employed for partially or completely closing the wound will be referred to later.

(*b*) *The axillary portion of the incision* extends from the upper and outer angle of the ablation incision along, or a little above, the anterior

FIG. 349. INCISION FOR THE COMPLETE OPERATION FOR A CARCINOMA OCCUPYING THE UPPER OUTER QUADRANT OF THE BREAST.

fold of the axilla to a point an inch or so below its junction with the upper arm.

(*c*) *The epigastric portion of the incision*, for the necessity of which we are indebted to Handley, is carried from the lower and inner angle of the delimiting incision downwards and inwards across the epigastric triangle to end at the opposite costal margin 2 to 3 inches below the infrasternal notch.

Reflection of the upper flap. The upper flap, which should be reflected first, is dissected upwards as far as the lower border of the clavicle and inwards to the opposite edge of the sternum. While this is being done the assistant facilitates the process by grasping the edge of the flap with suitable grip-forceps so as to keep it stretched upwards. It is both time-wasting and superfluous to apply forceps to any but the more freely bleeding points.

Securing the pectoral branches of the acromio-thoracic axis. These vessels, which arise from the thoracic axis (thoraco-acromial) a little below the middle of the clavicle, descend behind and at right angles to the interval between the sternal and clavicular fibres of the pectoralis major. To reach them this interspace is opened up first with the

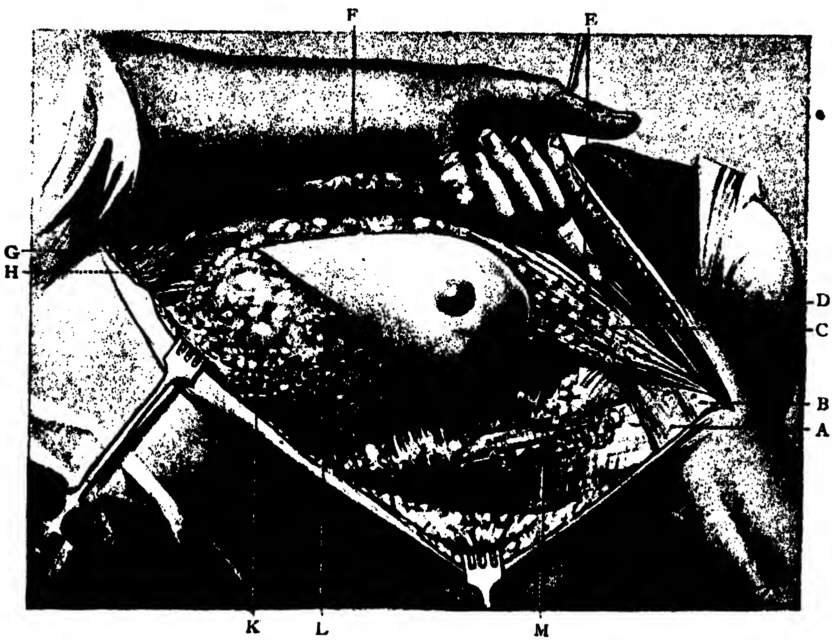


FIG. 350. THE COMPLETE OPERATION FOR CARCINOMA OF THE MAMMA. *Reflection of the flaps.* Shows the extent to which the upper and lower flaps must be reflected in order to remove the whole of the breast tissue, and a still wider area of superficial and deep fascia. The forefinger is inserted in the interval between the clavicular and sternal origins of the pectoralis major so as to hook forwards the pectoral branches of the acromio-thoracic axis and branches of the external anterior thoracic nerve. A, Fascia covering the coraco-brachialis muscle; B, Fascia covering the short head of the biceps muscle; C, Breast tissue covering the sternal fibres of the pectoralis major; D, Clavicular fibres of the pectoralis major; E, Pectoral branches of the acromio-thoracic axis and branches of the external anterior thoracic nerve; F, Sternum; G, Infrasternal notch; H, Aponeurosis covering the rectus abdominis muscle; K, External oblique muscle; L, Breast tissue; M, Fascia covering the latissimus dorsi muscle.

handle of the knife, and then with the left index-finger, which is thrust deeply through the costo-coracoid (coraco-clavicular) membrane so as to hook the vessels forwards along with the external anterior thoracic nerve; these are then divided between two artery forceps. By this preliminary step one of the main sources of blood-supply to the breast is

controlled at an early stage of the operation. Before proceeding to the next step the flap is covered with a large gauze swab wrung out of hot normal saline solution.

Reflection of the lower flap. The assistant now grasps and pulls the mamma towards him while the surgeon dissects back the lower flap to a little beyond the edge of the latissimus dorsi. The upper part of the flap is reflected so as to expose the outer wall of the axilla and the adjacent portion of the upper arm. During this part of the dissection it must be kept in mind that the lower part of the axillary vein lies immediately under the deep fascia, and that with the arm abducted the vessel is projected forwards by the head of the humerus. The lower part of the flap should be dissected down so as to lay bare the superficial fascia of the epigastric triangle as well as that covering the upper digitations of the external oblique muscle of the abdomen.

In dissecting back the flaps care should be taken to keep as close to the skin as is consistent with its vitality, otherwise one is very liable to cut into the breast tissue. This is especially important in the case of the lower flap, as the pectoral group of lymphatic glands when enlarged and diseased often lie close beneath the integuments covering the base of the axilla. If a malignant gland be accidentally cut into, it should be immediately removed, and, to avoid infecting the wound with cancer cells, a fresh knife should be taken.

Division of the insertion of the pectoralis major. The arm is slightly lowered by the nurse so as to relax the pectoralis major, the sternal fibres of which are divided from without inwards close to their insertion, the left forefinger being passed beneath the fibres so as to hook them forwards away from the axillary vessels.

Detachment from the chest-wall of the sternal portion of the pectoralis major along with the breast, the circummammary fat, and the deep fascia. The upper border of the sternal portion of the pectoralis major is grasped by the operator's left hand and put on the stretch, while the right detaches the subcutaneous fat and the origin of the pectoralis major from the sternum and costal cartilages from above downwards, the assistant meanwhile applying forceps to the perforating branches of the internal mammary vessels, if possible before they are divided. When the lower end of the sternum has been reached, the circummammary fat and deep fascia are dissected off the epigastric triangle along with the upper part of the anterior sheath of the recti, the muscular branches of the

superior epigastric artery being clamped. Next, the fat and deep fascia, along with the lower and outer part of the breast, are cleanly dissected off the upper digitations of the external oblique, the lower part of the serratus magnus, the pectoralis minor, and, finally, off the inner and posterior walls of the axilla as far back as the latissimus dorsi. The breast and pectoral muscle, with their deep surfaces directed upwards, are turned

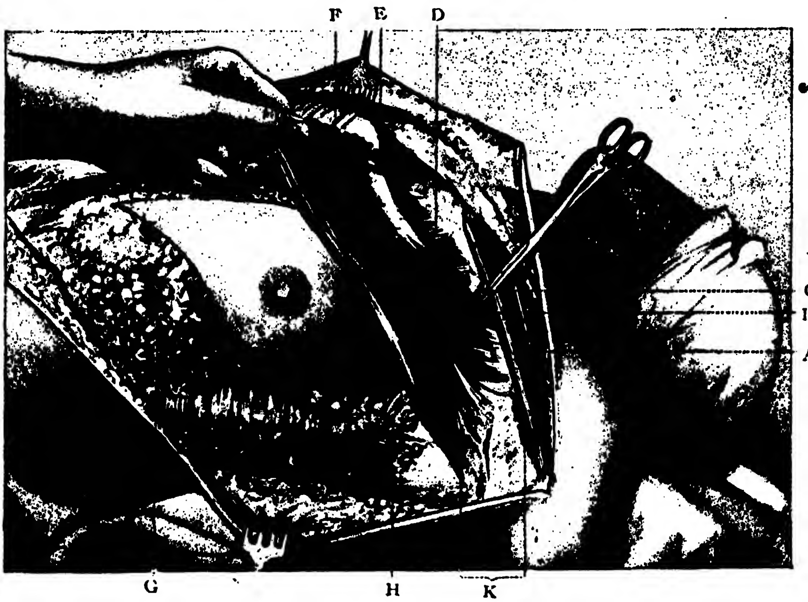


FIG. 351. FURTHER STAGE OF THE COMPLETE OPERATION FOR CARCINOMA OF THE MAMMA. *Division of the pectoralis major.* The pectoral branches of the acromio-thoracic (thoraco-acromial) axis are clamped and divided; the upper part of the sterno-chondral origin of the pectoralis major is detached, exposing the upper part of the pectoralis minor and the first intercostal space. A, Clavicular fibres of the pectoralis major; B, Pectoralis minor; C, Pectoral branches of the acromio-thoracic (thoraco-acromial) axis; D, First external intercostal muscle; E, Anterior perforating branch of the internal mammary artery; F, Upper part of the sternal portion of the pectoralis major turned downwards so as to expose its deep surface; G, Breast tissue; H, Latissimus dorsi muscle covered by fascia; K, Cut surfaces of the sternal fibres of the pectoralis major divided close to their insertion.

backwards over the posterior fold of the axilla, and left attached to the remaining fascia and fatty contents of the space.

Removal of the pectoralis minor. With a few touches of the knife the fascia at the upper and lower borders of the pectoralis minor is divided, and the finger is passed under the muscle close to its origin so as to hook it forwards while it is being detached from the ribs. The muscle is then reflected upwards and outwards and removed by dividing it close

to its insertion into the coracoid process. Blunt dissection may be employed to free the under surface of the muscle as it crosses the axillary vessels. The blood-vessels which supply the muscle will be found to enter its deep surface close to its insertion.

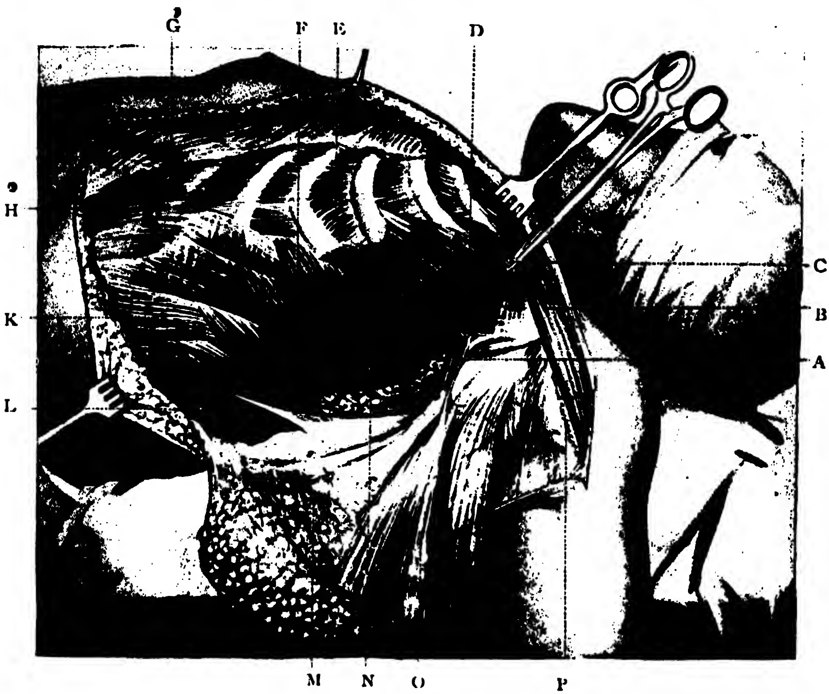


FIG. 352. FURTHER STAGE OF THE COMPLETE OPERATION FOR CARCINOMA OF THE MAMMA. *Exposure of the axilla.* The sternal portion of the pectoralis major, along with the breast, circummammary fat, and deep fascia, has been detached from the muscles of the chest-wall from within outwards and from below upwards, and folded back over the posterior fold of the axilla. The pectoralis minor is still in position. A, Internal anterior thoracic nerve; B, Clavicular fibres of the pectoralis major; C, Pectoral branches of the acromio-thoracic (thoraco-acromial) axis; D, Pectoralis minor; E, External intercostal muscle; F, Serratus magnus; G, Infrasternal notch; H, Left rectus abdominis muscle; K, External oblique muscle; L, Latissimus dorsi muscle; M, Retromammary fascia; N, Posterior thoracic nerve; O, Posterior surface of the pectoralis major; P, Divided sternal fibres of the pectoralis major.

Dissection of the axilla. The whole of the anterior wall of the axilla having been removed, the operator now proceeds to make a clean dissection of the axilla from above downwards, and not from below upwards as in the old operation.

The clavicular fibres of the pectoralis major are retracted upwards while the operator clears away the cellular tissue and fascia covering the upper two intercostal spaces. In continuing the dissection inwards

towards the vein the remains of the costo-coracoid (coraco-clavicular) membrane are removed along with the infraclavicular glands and fat. The sheath of the upper part of the axillary vein and the small superior thoracic vessels are also removed. Every particle of fatty tissue must be cleared away as high up as the sheath of the subclavius muscle, the first rib, and the subclavian vein, and when the subclavicular glands

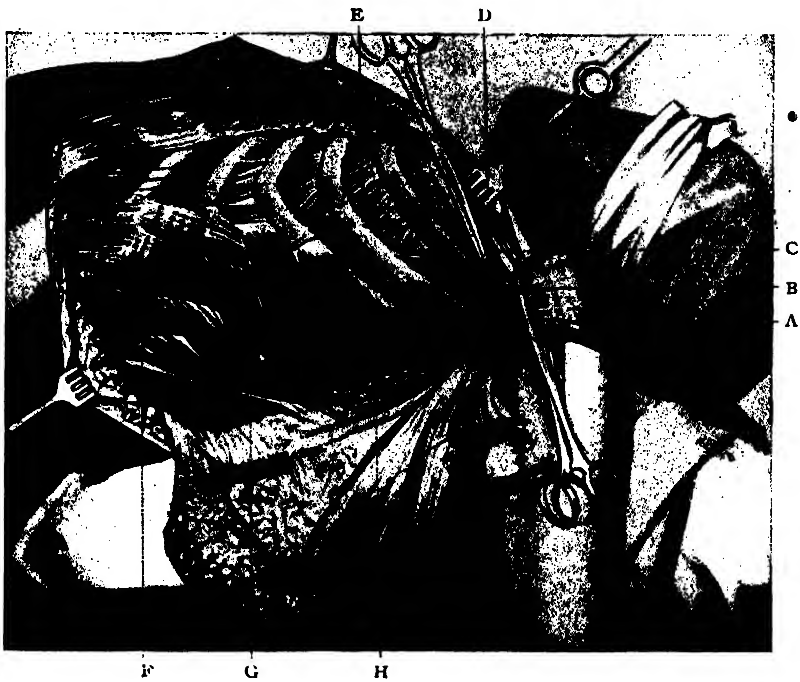


FIG. 353. FURTHER STAGE OF THE COMPLETE OPERATION FOR CARCINOMA OF THE MAMMA. *Division of the pectoralis minor.* The pectoralis minor has been detached at its origin and thrown upwards, exposing the blood-vessels which enter its deep surface close to its insertion. A, Deep surface of the pectoralis minor with blood-vessels, B, entering it; C, Clavicular fibres of the pectoralis major; D, Pectoral branches of the acromio-thoracic (thoraco-acromial) axis; E, External intercostal muscle; F, External oblique muscle; G, Serratus magnus muscle; H, Posterior thoracic nerve.

are extensively involved the clavicular fibres of the pectoralis major must be removed. The cephalic vein need not be injured. Not infrequently the axillary artery is freely exposed as well as the vein, and when the acromio-thoracic (thoraco-acromial) axis has to be ligatured, care must be taken not to divide it too close to its origin from the axillary. In separating the fat and glands from the remainder of the axillary vein the dissection should be carried from above downwards and from without inwards. The sheath of the vessel should

also be removed. Before dividing the tributaries of the vein, forceps are applied to them close to their termination, a stump being left to form a pedicle only just long enough to prevent the ligature from slipping. When the subscapular vessels are reached, at the level of the lower border of the subscapularis muscle, they are divided between two forceps at a little distance from the main vessels, and their distal portions are

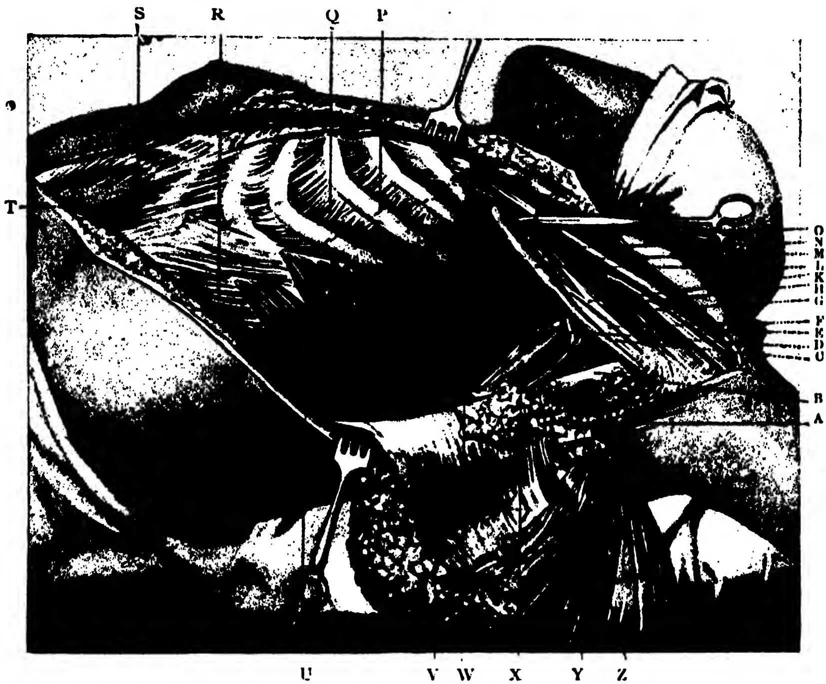


FIG. 354. FURTHER STAGE OF THE COMPLETE OPERATION FOR CARCINOMA OF THE MAMMA. *Clearing the axilla.* The pectoralis minor muscle has been removed and the axilla has been cleared from above downwards. A, Axillary fat and lymphatic glands; B, Tendon of the latissimus dorsi; C, Ulnar nerve; D, Long subscapular nerve; E, Cut edge of the pectoralis major; F, Internal cutaneous nerve; G, Coraco-brachialis muscle; H, Musculo-cutaneous nerve; K, Median nerve; L, Axillary vein; M, Cut edge of the pectoralis minor; N, Axillary artery; O, Clavicular fibres of the pectoralis major; P, Third rib; Q, External intercostal muscle; R, External oblique muscle; S, Infrasternal notch; T, Rectus abdominis muscle; U, Serratus magnus; V, Retromammary fascia reflected from the serratus magnus; W, Posterior thoracic nerve; X, Subscapularis muscle; Y, Subscapular vessels; Z, Posterior surface of the pectoralis major.

removed along with the fat and glands which surround them. During this procedure the dorsal (circumflex) scapular vessels are clamped and divided, but the long subscapular nerve can generally be isolated and preserved. When the subscapular chain of glands is especially implicated,

as is liable to be the case when the tumour is situated in the lower and outer margin of the breast, it is often necessary to remove the nerve along with the vessels. Unless the glands at the posterior wall of the axilla be extensively involved, it is seldom necessary to interfere with the structures which leave the axilla by passing through the quadrilateral

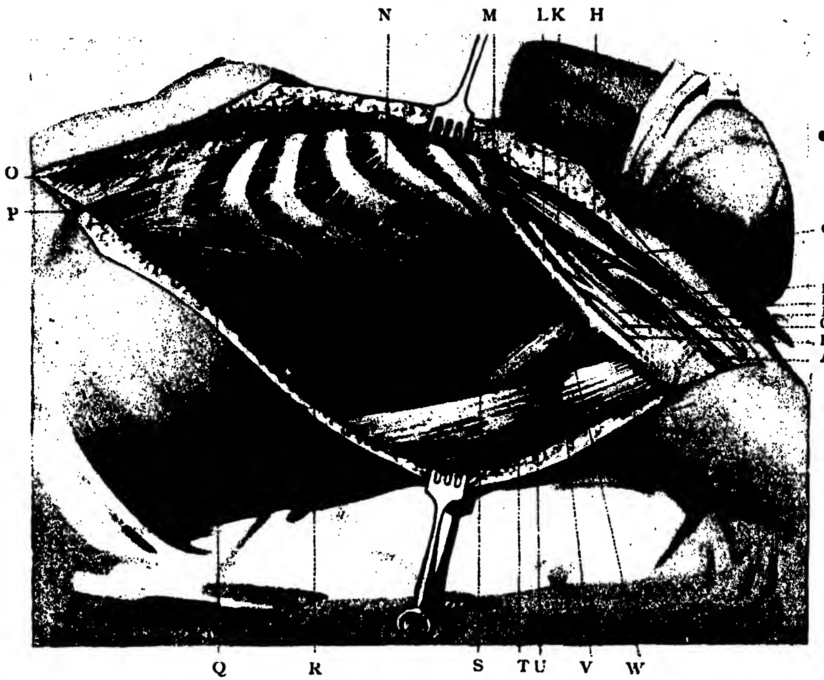


Fig. 355. Further Stage of the Complete Operation for Carcinoma of the Mamma. *The axilla cleared.* The breast, the pectoral muscles, and deep fascia have been removed and the axilla cleared. A, Coraco-brachialis muscle; B, Ulnar nerve; C, Internal cutaneous nerve; D, Cut edge of the pectoralis major; E, Median nerve; F, External cutaneous nerve; G, Cut edge of the pectoralis minor; H, Clavicular fibres of the pectoralis major; K, Axillary artery; L, Axillary vein; M, Subclavius muscle; N, External intercostal muscle; O, Infrasternal notch; P, Rectus abdominis muscle; Q, External oblique muscle; R, Serratus magnus muscle; S, Posterior thoracic nerve; T, Latissimus dorsi; U, Subscapularis muscle; V, Long subscapular nerve; W, Subscapular artery.

intermuscular space, *viz.* the posterior circumflex (humeral) vessels and the circumflex (axillary) nerves. The musculo-spiral (radial) nerve is sometimes exposed, but it is not likely to be injured.

Having exposed the axillary vein in its whole extent, the clearing out of the axilla is completed by making a clean dissection of its inner and posterior walls, that is to say, by cleaning the serratus magnus, the subscapularis, and the axillary portion of the latissimus dorsi. When

the axilla is comparatively free from disease, the fatty fascia can usually be stripped off the subscapular muscle by gauze dissection carried in a direction from above downwards and from without inwards. Unlike the long subscapular nerve, the middle subscapular is closely bound down to the muscle and is, therefore, protected from injury. The anterior part of the serratus having already been cleansed at an earlier stage of the operation, viz. when the lower and outer quadrant of the breast and deep fascia is dissected off the chest-wall, only the fat and fascia covering the posterior part of the muscle and the gutter-like interval between it and the subscapularis remains to be cleansed. The posterior thoracic nerve, which is met with at this stage of the dissection, can generally be preserved. The lower part of the gutter is bounded externally by the inner surface of the latissimus dorsi, between which and the serratus is a quantity of fatty tissue containing a plexus of veins formed by the anastomosis between the veins of the chest-wall and those which go to form the subscapular vein. In securing these vessels with forceps care should be taken not to include the branches of the long subscapular nerve just where they are about to enter the latissimus dorsi.

The breast and axillary contents, which are attached only in the region of the posterior fold of the axilla, are now completely detached by dissecting them off the outer aspect of the latissimus dorsi, and from the adjacent subcutaneous tissue at the attachment of the axillary portion of the lower flap. The nearer the primary tumour approaches the axillary margin of the breast, the further back should the fat and deep fascia be removed beyond the edge of the latissimus dorsi.

Either at this stage, or immediately before suturing the wound, it is a good plan, especially in well-nourished patients and in those possessing an abundance of breast tissue, to put the lower flap on the stretch with its raw surface directed upwards, while the operator, with a pair of large scissors curved on the flat, trims away any excess of the subcutaneous tissue upon its deep surface.

Before leaving the axilla the operator returns to its apex for the purpose of clearing out the recess which extends upwards behind the vessels towards the root of the neck. The vessels themselves are retracted upwards and outwards, and in clearing the space the upper part of the posterior thoracic nerve is again encountered; it is here accompanied by a vein which may give a little trouble if it is injured close to the axillary, into which it opens high up on its posterior aspect. When all the fatty tissue has been removed it will be found that the space does not extend uninterruptedly into the root of the neck, but that it is roofed in by a fairly well defined fascia. Unless the disease is advanced it is com-

paratively seldom that one finds the glands in this situation palpably diseased. If they should be, and if they are at all adherent to the apical fascia, it is advisable to clear out the supraclavicular triangle even although the glands in it are not obviously diseased.

As a rule, it will be found a comparatively easy matter to separate malignant glands from the axillary vein, provided one keeps inside the sheath. When, however, the sheath as well as the glands are firmly adherent to the vein, a portion of the latter must be resected. As a result of this procedure there is often a certain amount of œdema of the arm, but this is not likely to be permanent as long as suppuration does not occur, and provided also that the cephalic vein and the portion of the main trunk proximal to it are left uninjured.

Handley has shown that the persistent brawny swelling of the arm is not due to pressure of diseased glands on the vein, but to cancerous permeation followed by perilymphatic fibrosis and destruction of the lymph-vascular system of the deep fascial lymphatic plexus of the whole circumference of the upper arm, the result being that the lymphatic system of the breast is completely cut off from that of the trunk. In these distressing cases Mr. Handley has had good results from the 'introduction into the subcutaneous tissue of the swollen arm of a number of buried silk threads, running longitudinally upwards from the wrist to terminate in the loose and healthy areolar tissue in and beyond the axilla, and spaced out at convenient intervals around the limb', an operation which he proposes to designate as lymphangioplasty (see Vol. I, p. 408).

The axillary artery and main nerves, being separated from the glands by the axillary vein, are seldom involved until the disease has reached an advanced stage. It is true that a portion of the artery may be removed without gangrene occurring, but the probability is that in the cases calling for such a procedure the disease is so advanced that recurrence is practically inevitable. In one case, in order to remove the glandular disease, the writer was obliged to divide the acromio-thoracic (thoraco-acromial) artery so close to the main trunk that the latter had to be ligatured immediately above and below the origin of the vessel. No harm resulted, but the patient died ultimately of recurrence.

Ligature of the vessels and drainage. Before closing the wound all bleeding should be arrested, special care being taken to see that the ligatures are applied to the perforating branches of the internal mammary in such a way that they do not slip. In all cases in which the wound can be completely closed it is certainly wiser to drain the axilla by introducing a tube through a stab opening in the posterior flap immediately in front of the latissimus dorsi, about the level of the angle

of the scapula. The tube, which should be 3 or 4 inches in length and about the thickness of the little finger, is placed along the gutter formed by the junction of the inner and posterior walls of the axilla; it should not be so long as to cause pressure on the axillary vessels, and it is better to fix it to the skin opening with a suture rather than simply to transfix it with a safety-pin.

Closure of the wound. If the operation be performed by the long incision and extensive flap dissection above described, it is safe to assert that in cases in which the skin is neither visibly nor palpably involved the edges of the wound can generally be approximated. When, however, the skin is involved, and especially when the tumour is peripheral, some ingenuity and experience are called for in order to close the wound. In cases in which extra skin has been removed in the sternal region, the axillary flap, which is often a little redundant, can sometimes be made to fill in the gap. It not infrequently happens, however, that in attempting to close the gap by dragging the lower flap inwards, it becomes so tightly stretched across the axilla as to interfere with the abduction of the arm. To overcome this difficulty the lower flap must in the first place be dissected well back beyond the posterior fold of the axilla, and at the same time well freed from the upper part of the inner aspect of the upper arm. Having done this, an incision about 3 inches in length is carried backwards into the flap at right angles to the main incision, beginning at a point about 2 inches below the apex of the axilla. By this extra incision the skin which roofs over the axilla can be turned downwards and inwards and stretched across the chest-wall so as to meet the upper flap. The V-shaped gap which is left in the axillary portion of the lower flap is filled in by bringing down the somewhat triangular projection of the upper flap which exists at the junction of the ablation and axillary portions of the main incision (see Fig. 356). By this procedure, which is as simple as it is valuable, the redundant skin of the axilla is utilized to fill in the gap without leaving behind a tight band which would interfere with abduction of the limb by anchoring the upper arm to the side of the chest. Mr. Handley objects to making the original axillary incision along the anterior fold of the axilla on the ground that it leaves a cicatrix which, by its contraction, is liable to interfere with abduction by dragging on the arm. The writer has almost invariably carried his incision a little in front of the anterior fold of the axilla, and he has always found that the complication referred to by Mr. Handley is effectually prevented by the additional incision above described. Mr. Handley prefers to curve the axillary portion of the incision downwards towards the posterior fold. The advantage, however, of including the skin of the axilla in the lower rather

than in the upper flap is that it can be more conveniently made use of for plastic closure of the wound.

When the tumour is situated towards the outer margin of the breast, and a more or less V-shaped or tongue-like additional portion of skin has been ablated from the lower flap, the gap in it can sometimes be filled in simply by dissecting the flap considerably further back and closing the deficiency by uniting its edges at right angles to the main wound. In other cases, especially when an extra amount of skin has been removed towards the inner margin of the breast and the addition of a straight

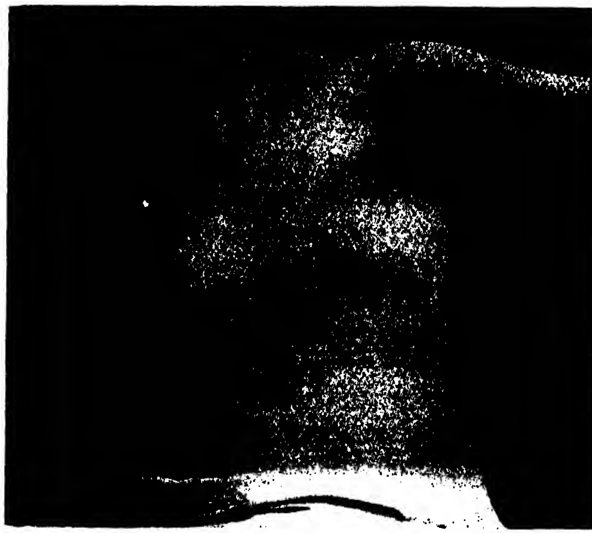


FIG. 356. CICATRIX LEFT AFTER COMPLETE OPERATION FOR CANCER OF THE MAMMA. A plastic closure of the wound was effected by turning in a flap from the axilla in the manner described on p. 675. The dots have been placed at the extremities of the various parts of the cicatrix.

incision carried backwards into the lower flap at right angles to the main wound is not sufficient to meet the case, a flap may be dissected up from the lateral aspect of the chest and turned inwards, according to the following method introduced by Warren. An incision is carried from the edge of the posterior flap at the level of the lower part of the axilla at right angles to the long axis of the main wound for about 3 inches, after which the knife is carried vertically downwards parallel to the edge of the main incision for about 4 inches. The somewhat tongue-shaped flap is then dissected down and turned forwards and inwards across the gap so that its extremity may be stitched to the inner edge of the main wound. In some cases, instead of making one large

flap as described above, it is more convenient to turn in two smaller ones according to the earlier method employed by Warren.

Another method which contributes towards the closure of the gap is to undermine the upper inner flap more extensively, and to dissect the opposite breast off the pectoralis major muscle, so that it can be dragged over towards the affected side. The anterior perforating branches of the opposite internal mammary artery are divided and must be ligatured. The extent to which the size of the gap can be reduced by this plan is rather disappointing unless it be carried to an extreme degree, which is undesirable on account of the deformity which it produces.

When the skin is so extensively involved that a large 'dinner-plate' incision is called for, it is impossible, especially in spare women, to close the wound completely by any plastic operation, however skilfully planned. Having closed the wound as far as possible, the raw surface which remains should be covered with Thiersch grafts taken from the front of the patient's thigh. This should be done at the same operation rather than subsequently, and if the assistant has had some experience in cutting the grafts, and has them ready prepared by the time the surgeon has completed the suturing, the process adds very little to the duration of the operation and practically nothing to its risk. The grafts should be cut as large as possible; they should be applied with their edges slightly overlapping, and before applying the dressing care should be taken to see that all air-bubbles are pressed out from beneath them, and that their edges are well flattened out. The grafted area should be covered with silver foil, according to the plan originally introduced at the Johns Hopkins Hospital, or with strips of gutta-percha tissue. The raw surface left on the thigh is covered with either of these materials, over which is applied a sterilized gauze compress, fixed either with a bandage or with strips of adhesive plaster applied spiral fashion.

In closing the wound the writer prefers to use interrupted sutures. They take rather longer to introduce than a continuous suture, but they possess the advantage of allowing a certain amount of the wound exudate to escape between them, and they are better adapted for plastic work. Silkworm-gut is used for the deeper sutures, while horsehair will be found most suitable for the intervening superficial sutures.

Dressing of the wound. To cleanse the large skin area previous to the application of the dressing, a good plan is to cover the whole of the front of the chest and upper abdomen with a large gauze swab soaked in a 1% solution of lysol. By pressing the wet gauze firmly against the skin, it will be found on removing it that the surface is freed from blood. Any excess of lysol is then wiped off and a large square of several-ply gauze, wrung out of warm normal

saline or of a very weak carbolic or sublimate solution, is applied over the front of the chest and abdomen, well down below the umbilicus. Over this is placed a liberal supply of sublimated wool. The patient is then carefully rolled well over towards the sound side while a similar dressing is applied to the back, care being taken to see that plenty of sublimated wool is used, as it is here that the wound exudate is most likely to reach the surface. Before applying the posterior dressing, however, the soiled sheet upon which the patient has been lying should be removed and a clean one substituted. Too much stress cannot be laid on the importance of applying the dressing over a wide area after the operation for cancer of the breast. In addition to covering the chest and axilla the dressing should extend down to the pelvis and well up to the neck; an extra pad of wool is placed over the base of the axilla, and the upper arm should be covered in down to the elbow. The dressing is secured in position by means of two or three domet bandages which should be carried over the top of both shoulders.

The limb should be placed with the upper arm abducted to the level of the shoulder, the forearm being left free and merely comfortably supported on a pillow in the pronated position with the elbow flexed to about a right angle. No splint is required if the shoulder and upper arm be surrounded with plenty of wool secured in position by a well-applied domet bandage, but if the patient be unduly restless for the first few hours after the operation, the upper arm may be secured to a sand-bag placed between it and the chest-wall. This position of the limb, which was advocated by the late Mr. Edward Cotterill, is a great improvement on the old method of bandaging the arm to the chest—indeed it is safe to say that if the limb be maintained in the abducted position from the outset the functional results are all that can be desired.

AFTER-TREATMENT

As the operation is necessarily a severe one, a slight degree of shock is inevitable. This, however, can readily be combated by the introduction of a liberal amount of normal saline into the rectum by the drop-method introduced by Murphy; a quart should be introduced immediately after the patient has been put back to bed, and, if necessary, this should be repeated once or twice, at intervals of six hours.

If due care be exercised in ligaturing the bleeding points, any reactionary hæmorrhage which occurs should not be sufficient to call for active treatment. It is only in the event of a ligature slipping that it may be necessary to open up the wound for the purpose of suturing the bleeding

point. It not infrequently happens, however, that the normal exudate is sufficiently copious to soak through even an abundant dressing. In such a case it is seldom necessary to change the dressing until it is time to remove the drainage tube; it usually suffices to place beneath it a sheet of sublimated wool thickly dusted with boracic powder.

Most authorities recommend that the drainage tube should be removed at the end of forty-eight hours, some even at the end of twenty-four hours. During recent years the writer has been in the habit of leaving the tube in for three days, in order that the patient may be left undisturbed until she is better able to bear the fatigue of having the dressing changed. Another advantage of leaving the tube in for an extra day is that, owing to the division of the main lymphatics at the apex of the axilla, the escape of lymph may continue for some days, while in exceptional cases the flow amounts practically to a lymphorrhœa. When this occurs a special gauze pad should be so arranged as to exert pressure over the infra-clavicular region and the apex of the axilla.

The removal of the tube and the first change of dressing should be carried out in such a way as to prevent the possibility of infecting the wound, and at the same time with as little disturbance of the patient as possible. Two assistants are necessary, one of whom should support the arm while the other keeps the dressing in position during the application of the bandage. The patient need not be raised into the sitting posture until the bandage is about to be applied. After cutting and turning aside the bandage a sterilized sheet is spread over the bedclothes below the wound, so as to prevent any possibility of them coming into contact with it. The dressing is then removed from the front of the chest and a fresh one applied, the same care being taken as at the operation to see that it extends well wide of the wound. With the patient next turned gently towards the sound side the tube is removed, after which the posterior part of the dressing is drawn out and a sterilized sheet is pushed in below the patient so as to protect the skin from the bedclothes. The bandage is then applied, the arm being maintained as before in the abducted position. A little sublimated iodoform-bismuth paste (see Vol. II, p. 9) may be smeared over the drainage opening, and it is an advantage to wipe the apex of the axilla with a swab moistened with a carbolic or sublimated solution; there is no need, however, to swab the whole wound area with an antiseptic lotion.

After the third day the patient is generally strong enough to be propped up in the sitting posture for the greater part of the day. She may move the forearm to any extent provided that she does not move the shoulder as well. The dressing need not be changed again until a week later, that

is to say, until the tenth day after operation. As a rule, all the stitches may then be removed, but should the skin at some part of the wound be considerably stretched, the stitches in that particular region should be left in for a few days longer. Should there be a tendency to sloughing at the seat of tension, a little sublimated iodoform-bismuth paste may be applied to keep the region aseptic, and a little of the same material may be smeared over the stitch openings. The axilla is bathed with a little lysol, or a 5 % solution of carbolic, and a dry sterile gauze dressing is applied. After this dressing the patient may be allowed up in a chair for an increasing period each day. A few days later the dressing may be dispensed with, all that is necessary being to protect the recent scar by stitching a sheet of boric lint inside whatever garment is worn next the skin. It is safe to allow the patient to leave the hospital on the twelfth or fourteenth day.

MODIFICATIONS OF OR ADDITIONS TO THE OPERATION

Ulcerating or fungating carcinomas. When operating on fœtid ulcerating or fungating carcinomas of the breast, it is the duty of the surgeon to do all in his power to prevent septic infection, a very dangerous complication if the whole wound becomes involved.

If the ulcer be small it may be disinfected either with the actual cautery or by means of the free use of pure carbolic acid. When, however, the ulcerating area is more extensive or when it is replaced by a large fungating and septic mass, it has been the writer's practice, in cases in which there is a possibility of obtaining a permanent cure, to do the operation in two stages. At the first operation only the diseased area and breast are removed, care being taken not to open up the axilla. The wound may be partly sutured, but no attempt should be made to close it entirely. Ten days or a fortnight later, when the wound is covered with healthy granulations, the operation is completed by removing the pectorals and clearing out the axilla in the usual way.

When the disease in the axilla is extensive. When the disease in the axilla is obviously extensive and it is questionable how far it is possible to remove it, the proper course to adopt is to begin the operation by exposing the axilla. This is done by making a T-shaped incision, one limb of which corresponds to the anterior fold of the axilla, while the other is carried from its centre upwards and slightly inwards to the junction of the inner and middle thirds of the clavicle. After reflecting the flaps the base of the axilla is opened into by dividing the deep fascia along the lower border of the pectoral muscles, while the subclavicular region is exposed by opening up the interval between

the sternal and clavicular fibres of the pectoralis major, the pectoral branches of the thoracic axis being hooked up with the forefinger and divided between two artery forceps. By retracting the two portions of the pectoralis major and opening up the interval as widely as possible, the costo-coracoid membrane is divided and the upper border of the pectoralis minor is exposed and retracted downwards.

The infraclavicular glands and the first part of the axillary vessels are now exposed, and if it be already evident that the disease is irremovable the operation should not be proceeded with unless the conditions are such that a radical operation is likely to prove sufficiently palliative and life-prolonging to make it justifiable. In order to decide this question it will generally be necessary to cut across both pectoral muscles so that the extent of the disease may be more fully investigated. The writer has one patient alive and apparently free from recurrence three years after operation, the glands in her case being so fixed to the axillary vein that three inches of it had to be resected.

If the disease in the axilla be so extensive that it is deemed useless to perform even a palliative operation, the wound should be closed without interfering with the breast itself. If, on the other hand, all visible disease in the axilla can be removed by resecting a portion of the vein, the operation should be completed by removing the breast in the radical manner already described.

Removal of the supraclavicular glands. Surgeons are by no means at one as regards the indications for removing the supraclavicular glands. Halsted, in a valuable paper published in the *Annals of Surgery*, July, 1907, deals with the results of 232 radical operations performed at the Johns Hopkins Hospital. 'The neck operation was done in 101 cases primarily and in 18 secondarily. . . . In 14 patients the glands of the neck as well as the axilla were involved. Three of these, or 7%, were, it seemed, definitely cured.' In each of these three cases the glands were cancerous both to the naked eye and microscopically.

According to Halsted, the operator 'should surely perform the supraclavicular operation, barring, of course, special contra-indications, (1) in all cases with palpable, operable, neck involvement; (2) when the apex of the surgical axilla is involved. When mid-axillary involvement is demonstrable at the operation apical implication is almost certain, and hence (3) in these cases also the neck should be typically cleaned of its lymphatics, as high, at the very least, as the bifurcation of the carotid. We find ourselves for the past two years again performing the neck operation in most cases. We omit it in hopeless cases, in most "duct cancers", and in some carcinomata of emphatically

adenomatous type in which the axilla at operation is not macroscopically involved.'

In the present state of our knowledge, it is probable that the majority of surgeons will regard the third indication as insufficient, and there are so many exceptions to the other two as to make the neck operation the exception rather than the rule. Meyer does not appear to be in favour of clearing out the supraclavicular space at the time of operation in the absence of clinical evidence of the presence of cancerous glands in this region.

In the cases operated on by Meyer in which the supraclavicular glands were involved, none of the patients lived longer than nine months after the operation. In spite of this Meyer is of opinion that if the supraclavicular glands are enlarged they should be removed in every instance. He points out that diseased supraclavicular glands are met with more frequently when the primary tumour occupies the upper hemisphere, especially if the skin and subcutaneous tissue be involved as well.

Rodman invariably explores the neck in growths situated in the upper part of the breast because, as he points out, some of the lymphatics from the upper hemisphere pass superficial to the clavicle to join the supraclavicular glands, and the latter may be involved early in the history of cancerous growths located in the upper hemisphere. The writer is of opinion that the supraclavicular region should be cleared in those cases in which the glandular infection has extended upwards along the posterior thoracic nerve *behind* the axillary vein into the root of the neck.

When diseased glands can be felt to extend inwards behind the sternomastoid muscle so as to occupy the angle between the subclavian and internal jugular veins, it is probably wiser not to operate. In these cases it is highly probable that the disease at the inner part of the root of the neck is an extension upwards of infection already existing in the mediastinum. In all probability, too, by this time the disease has already reached the venous system through the thoracic and right lymphatic ducts. Too much must not be expected, therefore, from neck operations, either primary or secondary, in the treatment of cancer of the breast. Should cancerous supraclavicular glands already exist when the patient first presents herself for treatment, each case must be judged on its own merits, and before deciding to operate every attempt should be made to exclude mediastinal, pulmonary, hepatic, and osseous metastasis. If an operation be deemed advisable, the neck should first be explored, and should it be found impossible to remove all the disease, the breast operation should not be proceeded with unless there is reason to believe that it will prolong life and diminish suffering.

To gain access to the supraclavicular glands the upper limb of the

T-shaped incision already described for exposing the infraclavicular glands is prolonged upwards along the posterior border of the lower half of the sterno-mastoid muscle. Or, instead of carrying the incision upwards from the axillary extension of the breast incision, the supra-clavicular region may be exposed by a separate angular incision, one limb of which is placed parallel to, and a little in front of, the lower half of the posterior border of the sterno-mastoid, while the other limb corresponds to the middle two-fourths of the clavicle. The triangular flap thus marked out is dissected upwards and backwards.

The further steps in the dissection for the removal of these glands have already been described by the writer in his article on excision of tuberculous glands (see p. 16).

DANGERS OF THE OPERATION

Considering the size of the wound and the severity of the operation the immediate mortality is remarkably low. Out of 2,133 operations collated by Rodman from the practice of twenty-one American surgeons, between the years 1893 and 1903, the death-rate was less than 1 %. The writer has had one death as the result of the operation in upwards of 150 patients operated on by him ; the cause of death was sepsis, which occurred during the organization period of a hospital in which the technique had been out of date. The other complications which have proved fatal are pneumonia and bronchitis, hæmorrhage, shock, and pulmonary embolism. To minimize the risk of pulmonary complications the temperature of the operating theatre should not be below 65° F. The field of operation should be surrounded with dry sterile sheets in preference to wet carbolic towels, and the operation should not be unduly prolonged. If ether be the anæsthetic employed it should be administered by the open method rather than by the Clover apparatus. In elderly patients with a tendency to bronchitis, chloroform should be used in preference to ether.

PROGNOSIS AS REGARDS PERMANENT RECOVERY

The *ultimate results* of the operation are, of course, influenced by the variety of the cancer, the extent of the disease, and the thoroughness of the operation.

Sir Watson Cheyne's results, published in 1904, show that 50 to 55 % of the patients operated on by him were alive and well six to thirteen years after operation. These statistics do not include cases in which it was obviously impossible to remove all the existing disease.

This subject was dealt with by various surgeons at the Meeting of the American Surgical Association in 1907. Halsted, after excluding

sixty-five cases in which it was obvious that all the disease could not be removed, gave the results in 232 cases in which the complete subclavicular operation was performed at the Johns Hopkins clinic. The eighteen cases which could not be traced were tabulated as dead of the disease. In the sixty-four cases in which no glandular involvement was discovered it was found that in fifteen (23·4 %) the disease remanifested itself either in the form of a local recurrence or of a metastasis. As pointed out by Halsted, these cases show the necessity for wide operation even although the disease is in the early stage. No less than 80 % of the patients in whom glandular involvement could not be demonstrated were free from signs of the disease for three years. Of the 110 cases with axillary involvement and negative neck involvement, twenty-seven cases, or 24·5 %, were cured for periods ranging from sixteen to three years. By adding eleven untraced cases with axillary involvement to the 110 in which the result was definitely known, the percentage of cures in this category was reduced to 22·4 %. Halsted comes to the conclusion that in the early stage of the disease the modern extensive operation cures two out of three patients, while three out of four patients succumb who are operated on after the axillary glands have become demonstrably involved.

Willy Meyer, of New York, gave the end results of eighty-four patients operated on by himself during the twelve and a half years previous to the meeting. 44 % lived from three to twelve and a half years after operation; 50 % died of the disease within three years after operation, eight of these from internal metastasis without any local or regional recurrence.

At the same meeting Drs. Greenough, Simmons, and Barney gave, in a joint communication, the end results of 376 primary operations for carcinoma of the breast performed at the Massachusetts General Hospital during the ten years prior to January 1, 1904.

As regards the *extent of involvement,* it was found that when the tumour was not adherent to the skin, 32 % of cures were obtained as against 16 % when the tumour was adherent. Only 11 % of successes were recorded when the tumour was adherent to the chest-wall, whereas 21 % were free from recurrence when no such adhesion existed.

'Enlarged glands in the axilla were felt before operation in 236 cases, with 12 % freedom from recurrence. No glands were felt in 117 cases, with 29 % successful results. This suggests that absence of palpable enlargement of the axillary glands is a favourable indication, in spite of the fact that the glands removed as a routine measure are almost invariably found to be malignant.' Palpable enlargement of the glands above the clavicle occurred in forty cases, of which only two survived, and those were cases in which the enlarged glands were removed and found

not to be cancerous on microscopic examination. No cases recovered in which palpably enlarged cancerous glands were detected in the neck. All the six cases in which both breasts were involved died of the disease. Of sixty-six cases in which the tumour had progressed to ulceration, 6·6 % of recoveries took place, while of 316 cases in which no ulceration was present, 21 % were free from later recurrence.

With regard to the influence of the *variety of the cancer*, medullary carcinoma gave 16 % of cures, scirrhous cancer 23 %, adenocarcinoma 47·6 %, colloid cancer 66 %. 28 % of cures were obtained after operations for cancer in lactating breasts. It is interesting to note that only 12·5 % of cures were obtained in Paget's disease.

The statistics of these authors showed also the extent to which the results were influenced by the *amount of skin removed*. 'In sixty-seven of the complete operations so much skin was taken that a plastic operation or skin graft was necessary to close in the defect. The end results of these cases (19·4 % free from recurrence) were better than those in which the skin edges were readily drawn together (11·7 % free from recurrence), but showed most conspicuously in the matter of recurrence in the scar; 57·6 % of the plastic operations remained free from local recurrence in the scar, while only 44 % of the sutured wounds were thus successful.'

With regard to *late recurrence*, 'eighty-eight cases passed the three-year period without recurrence, but of these seventeen (19 %) showed metastasis later—exactly the percentage found by Schröder from a study of the cases at the Rostock clinic'.

Ransohoff, as the result of investigation by Labhardt, Koenig, Poulsen, Schröder, and Wunderli, has come to the conclusion that 'of those who have safely passed the three-year limit, about 20 % succumb later to recurrence *in loco* or to visceral, bone, or gland metastases'.

According to Smith, although 40 to 50 % of cases appear to be free from the disease three years after the operation, the percentage of permanent cures without this limitation falls to 17 %, and Barker asserts that 30 % of those living three years after operation ultimately die of the disease.

EXCISION OF THE MAMMA WITHOUT OPENING THE AXILLA

Indications. The more important conditions for which this operation is performed are: Diffuse lobular (parenchymatous) mastitis, especially when associated with the presence of multiple cysts; certain

cases of diffuse interstitial mastitis; tuberculous mastitis; cases of acute suppurative mastitis in which the breast tissue has been largely destroyed, and in which the organ is riddled with old-standing sinuses. The operation is also indicated when the breast is the seat of a neoplasm which, at first simple and slow growing, has taken on a more active growth, and when there is the slightest suspicion of local malignancy. Under this heading are included tumours of the fibro- and myxo-adenomatous type which are not truly encapsulated, as well as those which show signs of becoming sarcomatous, while of the tumours of the epithelial type must be mentioned those duct and cyst papillomata which show a tendency to invade the adjacent breast tissue.

Operation. The breast may be excised either with or without the removal of a portion of skin surrounding the nipple.

1. When the nipple and a portion of skin are removed, the typical incision takes the form of an ellipse with the nipple more or less in its centre (see Fig. 357, A). The direction of the ellipse is generally placed so that its long axis is a little nearer the horizontal than the vertical diameter of the organ, while its length as well as its width will depend, of course, on the size and configuration of the mamma. When the breast is pendulous the lower edge of the ellipse should be carried further away from the nipple than the upper edge, so as to bring the resulting cicatrix as low down as possible. Care should be taken to taper away the extremities of the ellipse sufficiently to prevent 'humping' of the skin by the suturing of the ends of the wound. Needless to say the typical incision may have to be departed from when the skin is involved at some distance from the nipple, or when sinuses are present.

In spare women, when the breast is neither well developed nor pendulous, care must be taken not to make the ellipse unnecessarily wide, as the extra tension required to close the wound is calculated to give rise to a broader cicatrix than would otherwise be the case. If the ellipse be made too wide the only way to minimize the mistake is to lengthen the incision so that the flaps may be more extensively undermined.

In dissecting the flaps off the breast it is of little or no moment which is taken first. The only advantage in beginning with the lower flap is that there is no chance of the field being obscured by blood trickling down from above. When the flaps have been dissected up sufficiently, the breast itself is seized with the left hand and rapidly dissected off the pectoralis major and serratus magnus, the separation being made in the loose cellular plane which intervenes between the deep surface of the corpus mammæ and the pectoral fascia. In the absence of special indications it is not necessary to remove the pectoral fascia.

In stripping off the breast it is well to begin at its inner margin and to cut with long rapid sweeps of the knife, carried mainly parallel to the fibres of the pectoral muscle, in a direction from above downwards in removing the right breast, from below upwards when the left breast is being removed. The bleeding is comparatively slight. A few vessels, chiefly veins, are divided in the subcutaneous tissue, while the only arteries worthy of being caught up are the two or three uppermost perforating branches of the internal mammary, the long thoracic, and one or two cutaneous branches of the intercostal arteries where they perforate the fascia covering the serratus magnus.

FIG. 357. INCISIONS FOR REMOVAL OF PART OR THE WHOLE OF THE BREAST. A, Elliptical incision for the removal of the breast without opening the axilla; B, The Thomas-Meyer incision for removal of a simple tumour, a cyst, or a portion of the breast by the retromammary route.

If the edges of the wound are to be united by a closely applied continuous suture without drainage, great care must be taken to ligature even the smallest bleeding points, otherwise a hæmatoma is liable to form under the flaps, especially if the vomiting which results from the anæsthetic be accompanied by much straining. When no drainage is used it is wiser to close the wound with an interrupted suture, preferably of silkworm-gut or horsehair. As a rule, to be on the safe side, it is better to introduce a small drainage tube through a puncture opening in the lower flap.

In applying the dressing the shoulder is included and the axilla well padded, but the arm should not be bandaged to the chest. By means of a modified spica bandage the arm is kept slightly abducted, and the

movements of the shoulder are at the same time sufficiently restricted. If a tube has been introduced it should be removed on the third day, after which the patient is allowed up with the arm supported in a sling.

If in performing the above operation the surgeon wishes to explore the axilla, all that is necessary is to prolong the outer extremity of the incision so as to divide the axillary fascia, after which the lower borders of the pectoral muscles are exposed and retracted upwards. 'Exploration' of the axilla, however, is an unscientific procedure, as the absence of visibly enlarged and palpably indurated glands is no proof of the absence of microscopic disease. Hence, if there is any question as to the possibility of glandular infection, the axilla should be cleared, and to do this thoroughly the pectoral muscles must be removed.

2. When the nipple and skin are healthy and non-adherent, it is often advisable, especially for cosmetic reasons, to excise the breast without removing the nipple. This procedure is peculiarly applicable in removing the breast for the diffuse form of chronic lobular mastitis associated with multiple cystic disease.

The operation is performed by making a semilunar incision along the thoracico-mammary furrow for an extent corresponding to the edge of the lower and outer hemisphere of the breast. The upper extremity of the incision ends at or immediately behind the anterior fold of the axilla (see Fig. 357, B). If the breast be large and pendulous, it is advisable, instead of making a simple curved incision, to remove a crescentic portion of skin.

The semilunar flap, which should include as much of the premammary fat as possible, is dissected off the corpus mammæ, care being taken not to button-hole it in detaching the nipple and areola. Before the operator attempts to dissect out the inner part of the organ, the circumference of the outer hemisphere is defined and freed, after which this half of the organ is dissected up off the serratus and pectoralis major as far inwards as possible. The operator now seizes the outer hemisphere with the left hand and pulls it well towards him while he undermines the skin covering the inner hemisphere, the assistant at the same time keeping the skin flap drawn well upwards. After the breast has been removed, the assistant everts the flap and protrudes its subcutaneous surface well into the wound, so that the bleeding points may be exposed and ligatured. The perforating branches of the internal mammary artery should be sought for and ligatured, otherwise a hæmatoma is liable to form after the flap has been sutured back into position. In any case, it is wiser to employ drainage, either by means of a strip of gauze or a small rubber tube.

The after-treatment is the same as described above.

PARTIAL RESECTION OF THE MAMMA

This operation is most frequently called for in the treatment of the localized form of chronic lobular (parenchymatous) mastitis with or without the presence of cysts, in the adherent fibro-adenomatous tumour-like growths due to chronic inflammatory hyperplasia of a lobule of the glands, in localized interstitial mastitis, in gummatous mastitis, and, more rarely, in the localized form of tuberculosis of the mamma. It is also the most satisfactory method of dealing with all simple cysts of the breast which are large enough to give rise to discomfort. The wall of all cysts of the breast is so intimately related to the surrounding fibrous stroma of the organ that it is impossible to remove it without taking away the portion of the organ in the immediate neighbourhood.

Operation. If the portion of breast tissue to be removed be situated either in the outer or in the lower hemisphere, the resection is best carried out by the retromammary route, a method first introduced by Galliard Thomas, and further elaborated by Warren. A curved incision is made along the thoraco-mammary fold, the length and position of the wound depending, of course, on the size and situation of the portion of breast to be removed (see Fig. 357, B). Even when the disease is situated in the upper and inner quadrant it is generally possible, by increasing the length of the incision, to deal with it by the same route; if not, a straight incision which radiates from the nipple must be made directly over the wedge to be removed. After the outer edge of the pectoralis major has been reached and the retromammary cellular space has been opened up to the full extent of the wound, the operator or his assistant grasps the breast in such a way as to protrude its posterior surface into the wound. The surgeon, after carefully palpating the breast tissue to ascertain how much should be removed, seizes the affected area with volsella or other suitable grip-forceps, and by means of two radial incisions resects a wedge-shaped portion, the apex of the wedge being directed towards the nipple. As pointed out by Warren, the wedge removed should not include the adipose layer which lies in front of the mamma, as its presence helps to prevent a subsequent depression. If a cyst of considerable size should be accidentally opened into, the further steps of the operation may be facilitated by stuffing the cavity with a strip of gauze. Should the cyst contain an intracystic epithelial growth, or should small cysts be revealed on the cut surface of the adjacent breast tissue, the question of the removal of the whole breast will have to be considered.

In excising a cyst or fibro-adenomatous nodule embedded in breast

which contains a good deal of adipose tissue, and which is less firm and compact than usual, it is often more convenient to carry out the resection by means of scissors than with a knife. The portion of breast removed should always be very thoroughly sliced up and examined in a good light, to make sure that the indurated area does not contain a small atrophic scirrhus, or the earliest stage of an adenocarcinoma, the latter condition being the form of malignant disease into which chronic parenchymatous mastitis (chronic cystic mastitis of König) is liable to develop, should the proliferating epithelial cells penetrate the walls of the acini and invade the surrounding connective tissue. It is in this class of case that the diagnostic value of the writer's nitric acid test is so helpful.

The oozing from the cut surface of the breast may be a little troublesome, as the application of ligatures to the small vessels of the breast tissue is often difficult in consequence of the compact nature of the fibrous stroma in which they are embedded. The breast tissue on either side of the V-shaped incision is approximated with a double row of buried catgut sutures, one adjusting the anterior edges of the wound and the other its posterior lips. When the corpus mammæ is poorly developed a single row of sutures is sufficient. By bringing the cut surfaces of the breast tissue firmly and accurately in contact, no space is left into which blood may accumulate, nor is any depression left on its surface.

When the operation is being done for cystic mastitis, Warren recommends that the remaining segments of the gland be incised by a series of radiating incisions, so as to lay open and bring about permanent disappearance of the smaller cysts. Cysts, the size of a pea, are snipped out with scissors. The number of radial incisions will depend largely on the amount of gland tissue present: as a rule, three or four are sufficient.

The writer is inclined to think that most surgeons will agree with him that when, in addition to a large cyst, or a cluster of smaller ones, others still smaller are scattered throughout the breast, the whole organ had better be removed. To leave a number of scars in the substance of a breast the seat of cystic parenchymatous mastitis is not only calculated to render the organ abnormally sensitive and tender, but, what is more important, leaves the patient with a breast which is both physiologically and mechanically damaged, and which, in consequence, is more liable to undergo malignant degeneration.

OPERATIONS FOR ACUTE ABSCESS OF THE MAMMA

A *premammary abscess* should be opened early by a comparatively small incision radiating from the nipple. The healing is hastened by curetting the wall of the cavity with a sharp spoon. If the abscess be small, one or two strands of iodoform worsted or gauze are introduced in preference to a drainage tube. These may be removed on the third day, after which healthy granulation and cicatrization rapidly occur, so that in many cases nursing of the infant need not be abandoned.

Care must be taken to distinguish between a simple localized engorgement of the breast and the early stage of an *intramammary abscess*. If an incision be made in the former condition severe hæmorrhage may result. In cases of doubt the milk should be examined for micro-organisms, and the indurated area should be carefully palpated morning and evening in search of any sign of softening or deep fluctuation. As soon as either is discovered, no time is to be lost in having recourse to the knife. Every possible means must be taken to prevent contamination of the abscess with saprophytic organisms, otherwise the abscess will go on discharging for a lengthened period, and persistent sinuses are liable to form. A general anæsthetic should be administered, as the part is much too tender to admit of the skin being thoroughly purified without it. The incision should have a direction radiating from the nipple, with the double object of sparing the vessels as well as the ducts. It should be made directly over the softened or fluctuating area of the phlegmon, and it should be at least large enough to readily admit the finger, which must be introduced into the cavity in order to freely break down the sloughing remains of the intralobular septa which separate the various loculi of the abscess. One or more counter-openings are often necessary, as free drainage is all important.

Phlegmonous inflammations of the breast should be treated on the same principle as those occurring elsewhere, and the surgeon will do better to err on the side of too free, rather than of too limited, incisions. If outlying suppurative foci are present, the wound should be opened out with retractors, and the foci removed with a sharp spoon, aided, if necessary, by scissors. If the infective process be allowed to extend from one lobe to another the whole gland may become destroyed. The wound, if larger than is necessary to admit a large drainage tube, may be partially closed by the introduction of one or two deep silkworm-gut sutures. The drainage tubes should not be kept in longer than is necessary, as they tend to favour the formation of sinuses. Irrigation of the abscess at the time of operation with a hot weak antiseptic or

sterile lotion has the advantage of washing away a quantity of sloughing tissue, while at the same time it arrests the bleeding. If the hæmorrhage proves troublesome the cavity should be firmly packed.

A moist antiseptic dressing is applied next the skin, and over this a liberal amount of sublimated wool. The bandage should be applied so as to exert as much pressure as the patient can comfortably bear.

An acute *retromammary abscess* should be opened through an incision at the margin of the lower and outer quadrant. After the pus has been evacuated, the breast, which had been previously floated up, may sink down and interfere somewhat with the drainage; when this happens, a second incision should be made towards the sterno-clavicular margin of the breast.

When *persistent sinuses* remain after puerperal mastitis the history is generally somewhat as follows: The sinuses have existed for several months or even for a year or so; they date back from the last puerperium, or, it may be, from the one before. The original abscess, which had been allowed to burst spontaneously, or had been imperfectly drained, was allowed to become infected with saprophytic organisms, and a succession of abscesses formed at different parts of the breast.

To bring about healing of the sinuses the patient should be anæsthetized, the sinuses should be thoroughly scraped, swabbed out with pure liquid carbolic acid, and stuffed with iodoform gauze. If the sinus be long and blind, it should either be laid freely open, or a counter-opening should be made and the channel stuffed. If this does not suffice, the whole sinus, along with a wedge of adjacent breast tissue, should be excised, and the surfaces brought together with catgut. Should the sinus proceed from a firm and deeply-seated induration, the possibility of superimplanted malignant disease must be kept in mind. In such a case the axilla should be carefully examined, and, if there be any doubt about the diagnosis, the surgeon must obtain the consent of the patient to remove the whole breast, should further investigation at the time of operation reveal a state of malignancy. When the breast is riddled with a network of anastomosing sinuses, excision of the whole organ is the only course open to the surgeon.

SECTION V

OPERATIONS UPON THE THORAX AND ITS CONTENTS

PART II

OPERATIONS UPON THE THORACIC WALL AND ITS CONTENTS

BY

RICKMAN J. GODLEE, M.S. (Lond.), F.R.C.S. (Eng.)

Surgeon to University College Hospital; Consulting Surgeon to the Hospital for Consumption, Brompton

CHAPTER II

OPERATIONS UPON THE THORACIC WALL AND THE MEDIASTINA

OPERATIONS FOR INJURIES OF THE CHEST

Surgical emphysema, whether arising from injury to the lung or some other part of the air-passages, at most requires to be provided with means of escape by means of punctures, but is usually best left alone, as it is sure to be absorbed. The only exceptions are where the swelling is very inconvenient from its size, when punctures will suffice, and the rare cases where it is accompanied by cellulitis, in which free incisions are called for.

Wounds of the lung, whether the result of bullet wounds, stabs, or fractured ribs, give rise to hæmorrhage and usually hæmoptysis. They are generally best treated by absolute rest and hypodermic injections of morphia, but if there is reason to think that the bleeding is continuing, and the loss of blood is becoming serious, it is good practice to make a free opening into the chest and to endeavour to stop the hæmorrhage by suture or ligature or tamponnade. In most cases it is probably wisest to use neither external sutures nor drainage tubes, though the former are needed if the wound be very large, and the latter if it be septic. Sufficient occlusion is obtained by means of a dry dressing kept in place with plaster. The further the injury is from the hilus of the lung, the more likely such treatment is to be effectual; in fact, wounds of the large vessels at the root of the lung are generally rapidly fatal. Hæmothorax requires no treatment unless serious pressure symptoms result. In this case a certain amount of the blood should be slowly withdrawn by an aspirator. Too rapid or too complete extraction may start the bleeding afresh. For this reason, and also because even severe cases often clear up remarkably well, it is generally recommended that the surgeon should be in no hurry even to aspirate, and still less to open the chest in search for the source of the bleeding.

Wounds of the great vessels. Wounds of the large arteries in the thorax are usually almost immediately fatal; but cases are recorded where the injury has not actually penetrated the vessel, and a traumatic aneurysm has resulted, and others in which the wound, though a penetrating one, has been temporarily plugged by the object which has inflicted the injury. There is at least one recorded case of

successful ligature of the innominate artery after partial resection of the sternum, and doubtless it would be the right practice in the rare cases that present themselves to deal in this way with a wound of any large vessel, either artery or vein, in the superior mediastinum. Indications for such operations will be found in the chapter dealing with the treatment of aneurysms, to which also the reader is referred for guidance as to the treatment of secondary aneurysms of the aorta.

For injuries to the *thoracic duct* see Vol. I, p. 408.

Hernia of the lung. It is convenient to discuss all forms of hernia pulmonis together.

Non-traumatic hernia of the lung results from some congenital or acquired weakness of the chest-wall. The signs should be unequivocal, but other conditions, such as lipomata in the posterior triangles and abscesses, have frequently been taken for herniæ. As a rule, no treatment is required, or merely the application of a pad, but it may be necessary to expose the tumour, and endeavour by some plastic operation to close the opening in the chest-wall.

Traumatic herniæ may exist with or without an external wound, and may be *immediate* or *consecutive.* Should a portion of lung protrude through an external wound, as sometimes happens if forced expiration with a closed glottis occurs at the moment of injury, the part which is protruded may swell and sphacelate. It may be possible to return this portion, if it be healthy, into the chest; but sometimes the better plan is to include it in a ligature and remove it, and then close the chest-wall if the wound be aseptic, or insert a tube if the wound be septic, or simply to apply a dry dressing without stitches or tube. The condition is a very rare one in civil practice.

OPERATIONS FOR CARIES AND NECROSIS OF THE BONY WALLS OF THE THORAX

It will be convenient to discuss the inflammatory diseases of the bony walls of the thorax, including the cartilages, together, and before passing to the treatment to say something about the pathology. Any of these structures may be affected by acute inflammatory changes as a part of general acute diseases, such as acute infective osteomyelitis or typhoid fever, and in such cases acute abscesses will develop.

These are, however, less common than the more chronic processes, most of which are tuberculous, but some result from typhoid fever.

An abscess resulting from caries or necrosis of the spine may follow one of the commoner routes, *i. e.* it may track downwards, guided by the anterior common ligament, and ultimately give rise to a psoas abscess,

or it may pass directly backwards and appear as a dorsal abscess. But sometimes a spinal abscess, even if originating from caries of the cervical spine, may burst into the pleura, or it may enter an intercostal space and, passing along it, point at the side or the front of the chest. This may lead to confusion of diagnosis, and if, as I have seen happen, it also bursts into the lung, a tympanitic abscess with a strong impulse on coughing results, which may baffle the diagnostic powers of the most experienced.

Caries and necrosis of rib and rib cartilage may affect the bone or cartilage, or start at the junction of rib and cartilage, or cartilage and sternum. In cases of necrosis a sequestrum forms and is embedded in an involucrum, except in the case of cartilage where no involucrum forms. The process is often confined to the deep surface, and the abscess then burrows in the subpleural connective tissue, giving rise to a localized 'peripleuritis'. Such abscesses may extend widely, involving secondary caries of other ribs or cartilages, and closely simulating empyemata. A similar burrowing process may take place below the pleura in the attachment of the diaphragm. More often, however, the process remains localized, and a cold abscess develops in the neighbourhood of the affected rib or cartilage.

Either surface of the sternum or the interior of the bone may be similarly affected, and caries of the joint between the manubrium and the gladiolus is common. If the abscess forms on the deep surface of the sternum it may extend into the mediastinum, causing one form of mediastinitis, or it may burst at the side of the sternum through an intercostal space, or it may track outwards between the pleura and the ribs, or it may point at the episternal notch or the epigastrium.

Bearing in mind therefore the great variety of these abscesses, it will be seen that it is difficult to lay down general instructions with regard to treatment, but there is one golden rule, *viz.* to avoid injuring the pleura if possible, as tuberculous pleurisy is likely to follow this accident.

If the abscess has started from the spine the track should be followed back until an opening as near as possible to the source of the disease is secured. This will involve removal of a portion of rib or ribs quite close to the spine, but may enable the surgeon to deal with the primary disease.

In the case of necrosis of rib it may be enough to remove the sequestrum; but if the disease be caries it is better to remove the affected portion completely unless this involves exposure of the pericardium, in which case scraping with a sharp spoon is indicated. In conducting these operations the utmost care should be taken to lay open all the ramifications of the abscess, which are often very complicated, and in my experience the best results are obtained by applying pure carbolic acid to the surface and treating it as an open wound. The use of sutures even to large wounds is, I think, a mistake.

Caries or necrosis of the anterior surface of the sternum requires no special comment. Abscess on the deep surface may call for trephining or cutting a hole in the bone with a gouge. Sometimes, however, an opening at the side of the sternum is sufficient. In this case the internal mammary artery is in danger. If wounded it will probably be necessary to remove a costal cartilage in order to secure it. If the joint between the manubrium and gladiolus be involved it must be scraped or gouged. This may lead to the complete severance of the two parts of the bone. The movements of the two parts during respiration are rather alarming, but I have not seen any permanent evil consequences follow.

REMOVAL OF TUMOURS OF THE CHEST-WALL

We have only to consider the operations for those tumours which involve the ribs and intercostal spaces or the pleura; those for the more superficial ones are dealt with in other parts of the work. It may, however, be mentioned in passing that some of those which will be referred to have originated in the more superficial structures.

The simple tumours of the ribs and sternum are such as occur in other bones, amongst which enchondromata, though far from common, are those most frequently met with. Many swellings diagnosed as enchondromata turn out to be examples either of tuberculous disease or of abnormality of shape or structure. The latter perhaps hardly deserve mention in a work on operative surgery were it not that they are so often mistaken for new growths by the patient and sometimes even by the surgeon. If it be borne in mind that the third and fourth rib cartilages are especially liable to a marked prominence anteriorly, and that all the rib cartilages are in normal persons somewhat tender on pressure, and if it be also remembered that a bifid rib does really fill up the intercostal space either above or below, and finally, that these deformities are accentuated or made more obvious by loss of flesh, such mistakes in diagnosis should seldom occur. If, however, it be found during an operation that a supposed case of tumour is really an abnormally shaped rib, there is no doubt that the rib should be left alone and the patient frankly informed of the mistake. His—or probably her—pain and anxiety will disappear just as well as if the supposed tumour were removed.

In operating upon enchondromata or other simple tumours of the ribs there are no special rules for the shape or size of the incisions. It only needs to be stated that it is not well to work with too small an incision, as every effort will have to be made to avoid the wounding of the pleura. Should, however, a pneumothorax result, it will probably do no more harm than is involved in the immediate interference with respiration and the hampering of the surgical procedures; that is, sup-

posing it is possible, after the removal of the tumour, to make an air-tight closure of the opening in the chest-walls.

One of the less common tumours of the chest-wall is cystic hygroma. The nature of the growth will probably have been diagnosed before the operation is commenced, but it is not unlikely that the fact of its passing through one or more intercostal spaces has not been suspected. These cases should be dealt with like those occurring in the abdominal wall or other inaccessible places; *viz.* by removing the external part and leaving the rest alone. The disease is harmless except for the deformity it causes, which is here of no consequence, and for the attacks of acute inflammation resembling erysipelas to which it is liable, but which in this situation are very unlikely to occur. It is essential to maintain strict antiseptic precautions until the wound is absolutely closed, as otherwise the erysipelatous inflammation above mentioned may set in.

Malignant tumours of the chest-wall may be primary or secondary. The primary tumours are practically always sarcomata, often chondro- or myxo-sarcomata. If diagnosed early an attempt should be made to remove them freely with a considerable portion of the surrounding chest-wall. As this necessarily involves a free opening of the pleura, it would be very much aided by the employment of the high-pressure or low-pressure methods of operating (see p. 703). It is obvious that the risk involved in such a case as that of König, in which in removing a sarcoma of the sternum both pleuræ and the pericardium were opened, would thus be much diminished; it is interesting, however, to know that the operation in this case was not fatal. If it be found that the growth has involved the lung, it will be necessary to carefully estimate the amount to which the infiltration has taken place, and if it appear possible to do so, a portion of the lung may be taken away, either clamping or ligaturing it beyond the region affected, or by simply cutting it through with Paquelin's cautery. The former method is, on the whole, recommended. Air-tight closure of the chest-walls should, when practicable, be secured.

Primary tumours of the pleura are seldom likely to be diagnosable early enough to allow of any attempt being made for their removal.

Most of the cases of secondary tumours of the chest-wall are those of recurrences after the removal of cancers of the breast. If small and superficial it is the rule to remove them as widely as possible, endeavouring to avoid the opening of the pleura. But these operations are seldom satisfactory, as the lymphatic affection usually extends further than can be detected by the eye, and recurrence is almost invariable. I do not think that extensive resection of the chest-wall when infiltrated with cancer is an operation which ought to be undertaken.

The same may be said of those cases where the growth has originated

in the lung and involved the chest-wall, the disease in these cases being almost invariably so extensive that its removal is impossible, or if possible it is almost certain to be followed by recurrence.

OPERATIONS FOR MEDIASTINAL ABSCESS

Suppuration in the mediastinum may result from caries or necrosis of bone, or from the extension of suppuration from some distant part, as when a post-pharyngeal abscess, or one resulting from angina Ludovici, or that following tracheotomy, is conducted downwards by the deep fascia to the back of the sternum; or it may originate from some of the contents of the mediastinum, such, for example, as strumous glands, or from injury or disease of the trachea, bronchi or œsophagus, pericardium, &c. From these general remarks as to causation, it will be seen that the process is sometimes acute, and often of a diffuse character, necessitating prompt attempts at relief by trephining or resecting parts of the sternum, or by resecting ribs in the neighbourhood of the spine, and that thc search for the pus is a difficult matter, and, even if successfully carried out, unlikely to save the patient's life. Sometimes the suppuration is chronic and accompanied by pressure symptoms like those of tumour. These cases do not demand such immediate treatment; the matter often reaches the surface by a process of burrowing, and the best place for the incision thus becomes apparent, probably at the episternal notch, in the posterior triangle, or through an intercostal space, or at the ensiform cartilage. But if the presence of pus be suspected, though its exact position is doubtful, it may be justifiable to open either the anterior or posterior mediastinum in the manner indicated in order to search for it. It is needless to say that great care must be adopted in exploring with the finger amongst the great vessels at the base of the heart, and that the use of an exploring trochar or fine forceps is inadmissible.

In the posterior mediastinum it is difficult to avoid injury to the pleura; but the operation is much confused if this accident should occur. The incision should be made near the middle line. If there be no guide to the locality of the abscess it is difficult to say which side should be selected, the dangers being about equal. Portions of enough ribs and a sufficient number of transverse processes should be removed to enable the surgeon to see as well as feel the parts exposed. It must be remembered that the front of the bodies of the vertebræ is 3 to 5 inches from the level of the skin, and that if the finger reaches to this depth it will be in close contact with the important structures that occupy the posterior mediastinum: aorta, pericardium, thoracic duct, &c., and that thus a mere exploratory operation is liable to be followed by a catastrophe from which there is no escape.

CHAPTER III

OPERATIONS FOR THE REMOVAL OF FLUIDS FROM THE PLEURAL CAVITIES

EXPLORATION OF THE CHEST

If the physical signs justify the exploration of the chest it is usually wise to employ some form of aspirator. If it be quite certain that the fluid, if any, is the pus of an empyema, or that the two pleural surfaces are adherent, there is no objection to the use of exploring trochars. These are useful instruments in many cases of thoracic surgery, especially for penetrating the lung after the chest has been opened. They should be of various lengths and sizes, but should always have full-sized handles (see Fig. 358).

I strongly recommend the use of the bottle aspirator as opposed to any form of needle fixed to a syringe, or to Dieulafoy's aspirator, in which it is difficult to regulate the amount of negative pressure. The needle of the bottle aspirator is easy to manipulate; the amount of negative pressure can be regulated to a nicety, and it is readily cleaned. The only objection to its use is that it is rather cumbrous, but it seems to be forgotten that a small bottle is often more convenient than a large one. One great advantage beyond those already mentioned is that if fluid be found, the one puncture suffices for its evacuation. The needles, or rather trochars, should be of various sizes and lengths, but none less than 3 or more than 6 inches (see Fig. 359). They should always have a lateral as well as a terminal hole. They should be constructed throughout of metal, no leather washers being permissible, as they are constantly perishing and causing leakages at the joints.

A very slight negative pressure, or even none at all, should be made in the bottle until the supposed site of the fluid is reached. The mistake of producing an almost complete vacuum is commonly made, the result being that flakes of lymph are sucked into the tube, and the fluid, if present, is not evacuated.

The use of small hypodermic syringes or others of a similar nature cannot be too strongly deprecated. They are untrustworthy instruments,

and to my knowledge have often been the cause of pernicious and avoidable delay in treating a variety of thoracic diseases.

In exploring the chest the normal position of the thoracic and abdominal viscera and vessels must be borne in mind, as well as the fact that these may be much altered by disease. Inflammatory conditions of the pleura even when effusion is present are more likely to diminish the extent downwards of the pleural cavity than to increase it, because during the early painful stage of pleurisy full inspiration does not occur, and the diaphragmatic and costal pleuræ become adherent before the onset of effusion.

Through the lower intercostal spaces it is easy to reach the liver and spleen, and the splenic flexure of the colon has been inadvertently punctured. Puncture of the liver and spleen, while usually free from danger, has been followed by serious or even fatal hæmorrhage. The idea of exploring them in this way should never be entertained if there be any suspicion of leucocythæmia, hæmophilia, or any condition which may interfere with the coagulation of the blood.

Exploratory incision of the pleural cavity cannot be performed without producing a pneumothorax except with the aid of the 'high-pressure' or 'low-pressure' method of operating. It is described in the following section.

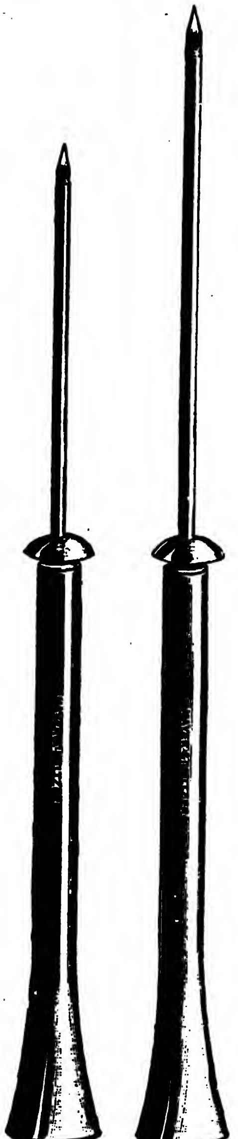


FIG. 358. EXPLORING TROCHARS. With large handles all of the same size. ¾ scale.

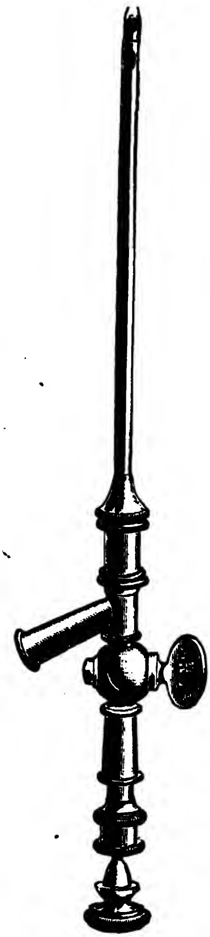


FIG. 359. ASPIRATOR TROCHARS. Suitable for exploring the chest. ¾ scale.

LOW-PRESSURE AND HIGH-PRESSURE OPERATIONS

Methods. Operations which involve the opening of the pleura have been hitherto, as far as possible, avoided on account of the fear of the evil consequences which may result from the production of a pneumothorax. It does not come within the scope of the present work to state what these dangers are, but it must be admitted that they are sometimes considerable, especially if the function of the opposite lung be in any way interfered with. At the same time, it is well known that small openings into the chest, allowing of the introduction of the fingers, and which necessarily produce a partial pneumothorax, may be made without danger, that even extensive wounds of the chest-wall are not necessarily fatal, and that in removing tumours of the chest-wall free openings have been made into the pleural cavity with only temporary interference with respiration. The pleura has thus remained to some extent a forbidden country as compared with the abdomen, the contents of which usually tend to protrude, or the skull, in which, as a rule, neither recession nor protrusion occurs.

Numerous devices have been made to obviate this difficulty; the simplest being the artificial production of adhesions, by suture, cautery, or caustics. This plan permits of the exploration by puncture or incision of the substance of the lung, but does not render possible the exploration of the pleural cavity itself.

It is only within the last four or five years that a new method of operating was suggested by Sauerbruch of Breslau, the principle of which consists in placing the patient's body in a chamber in which the atmospheric pressure can be lowered to any degree that may be required. The head remains outside and is subject to normal atmospheric conditions. It is thus possible, by regulating the amount of pressure inside the chamber, to ensure either that the lung remains in contact with the chest-wall when the pleura is opened, or to allow it to recede to any desired extent, or even, if desired, to make it protrude through the opening. It is obvious that this is an advance in surgery, and it has aroused much interest both in Europe and America, and has formed the subject of discussion at more than one surgical congress. The question of practicability at once arose. The apparatus is exceedingly costly, as may be gathered from the accompanying figure (see Fig. 360) reproduced from Lautenschläger's catalogue, and even if, in the course of time, the structure should be simplified and the cost reduced, it must always be a cumbrous affair, which could practically only be provided at a public institution, and it is hardly likely that even every large town in the country would be public-spirited enough to spend so much money in providing for what is, after all, not a very

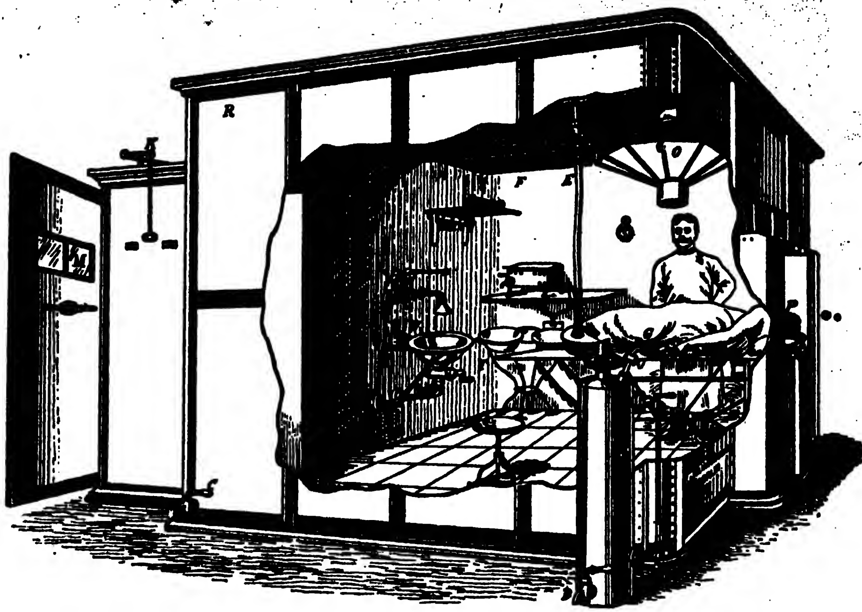


FIG. 360. SAUERBRUCH'S CHAMBER. R, the operating chamber, is made of iron plates, screwed together and painted inside with white enamel paint (it may, however, be supplied with windows, thus doing away with the necessity of artificial light, O). The floor is tiled and slopes so that water can escape by the tap C. There is an ante-room with double air-tight doors: the valve K, if opened, admits air into this antechamber and this allows of the opening of the outer door, M, which would otherwise be impossible. P is a projection through which the head and neck of the patient who is lying on the operating table, T, protrudes: his neck is surrounded by a closely fitting (almost air-tight) india-rubber collar. Above the projection P is a small window, N, through which the anæsthetist and the surgeon can communicate by signs; a telephone is also supplied for oral communication. G is an india-rubber bag which encloses the patient's body and is intended to maintain normal atmospheric pressure on the lower parts of the body; when secured in position (by means of cambric bandages) the tube E, which communicates with the outer air, is opened. W, H, A washing apparatus.

The low pressure is obtained by means of a powerful double-acting pump, which can be worked by steam, electricity, &c., and is by preference at some distance from the operating chamber in order to avoid vibrations: this apparatus is not shown.

If the doors and windows are hermetically closed, the necessary reduction of pressure (10 millimetres below normal atmospheric pressure) is obtained in from four to ten minutes, and can be rapidly either increased or diminished at pleasure. The amount of pressure must be observed on a water-pressure gauge, the position of which is immaterial. When the level of the water falls below 140 millimetres air enters the operating chamber through water contained in the vessel B. In this way the atmosphere is constantly renewed with moist and dust-free air and thus prolonged operation can be comfortably conducted. D is the tap for regulating the level of the water in the vessel B.

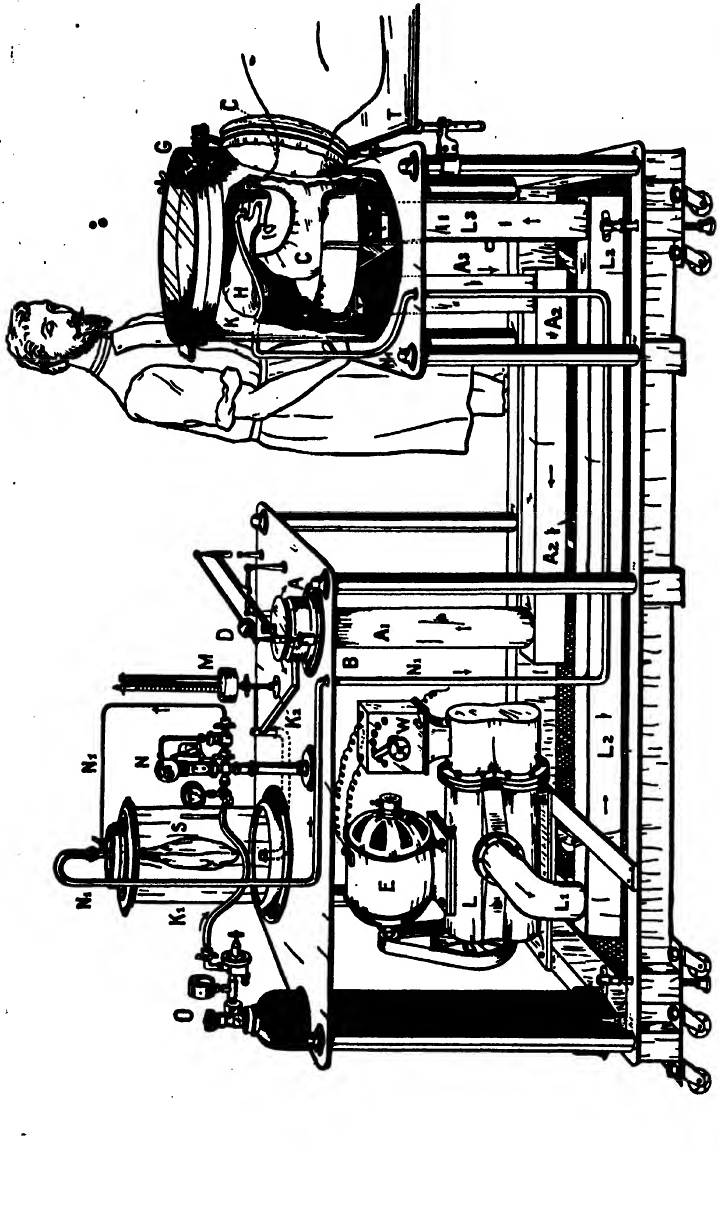


FIG. 361. BRAUER'S HIGH-PRESSURE APPARATUS. E, Electromotor; W, Starting-resistance and rheostat; L, Force-pump; L 1, L 2, L 3, Tube for conducting compressed air to high-pressure chamber; K, High-pressure chamber; A 3, A 2, A 1, Tube for conducting air from high-pressure chamber; A, Exit for air and apparatus for regulating the amount of the pressure; D, Weight for regulating the pressure; B, Water-brake piston, to avoid vibrations; M, Water manometer; O, Oxygen apparatus; N, Apparatus for the anæsthetic; S, Bag for holding the anæsthetic vapour; N 1, Tube for conducting the anæsthetic to the patient; P, Anæsthetic mask; K 1, Pressure regulator for the anæsthetic bag; K 2, Exit tube from pressure chamber K; G, Glass cover of high-pressure chamber—openable; C, C, Closely fitting covering or helmet and collar for patient's head and neck; H, Sleeves for the anæsthetist; T, Operating table.

large number of patients. Certainly no private individual would be likely to install one unless he had unusual opportunities of meeting with cases to be operated upon. There is, moreover, another objection to this low-pressure (*Unterdruck*) system. Not only must the patient's body, but the surgeon and his assistants also, be within the low-pressure chamber, while the anæsthetist, like the patient's head, is outside it. In case of respiratory difficulties the inconvenience of this arrangement is apparent. No oral communication except by telephone can take place between the surgeon and the anæsthetist, and in an emergency, such as in thoracic surgery is not uncommon, to resort to the telephone may be most undesirable, while to open a window for the interchange of words would raise the pressure inside the chamber to that of the outer air. If the opening in the chest were small it could, of course, be plugged, but if it were large it is likely that a suddenly caused pneumothorax would be added to the already present dangers of the patient. While, therefore, the advocates of the *Unterdruck* method can record some most interesting and important results, and while some of them still maintain its superiority to all others, one hears reports from many quarters that, for the reasons I have given, it is hardly practical, at all events at present, for general employment.

The possibility of preventing the collapse of the lung having, however, been demonstrated, attempts were made to obtain the same result in another way, *viz.* by increasing the pressure inside the lung instead of diminishing it outside. This high-pressure (*Überdruck*) method is associated with the name of Brauer, who in 1905 brought forward his method. I reproduce another figure from Lautenschläger's catalogue (see Fig. 361), a study of which will enable the reader to understand it and probably, if he desires it, to have a similar or possibly a simpler and less expensive one constructed, for even this, at the present time, costs something not far short of two hundred pounds. The advantage of this method over the other, besides the smaller size and more moderate cost of the apparatus, is that both the surgeon and the anæsthetist are in the open and free to communicate with one another, to resort to artificial respiration and adopt in concert any other procedures that the exigencies of the case may demand. The disadvantages which on first reading about the two methods appeared to me to outweigh all the advantages of it as compared with the *Unterdruck* method, but which those who have tried it do not say much about, is that the head of the patient and the hands of the anæsthetist are contained in a closed chamber, and I fail to see what would happen in the not unlikely contingency of the occurrence of hæmoptysis or vomiting, or the expectoration of the contents of an abscess. The anæsthetist must clearly have a copious supply of apparatus—gag, forceps, mops, towels, &c. —within the chamber, and must be well trained to employ them under

circumstances which to one who has not seen such operations would seem likely to be of great difficulty. It must be added that many surgeons speak highly of Brauer's apparatus, and appear to think that it will be found of practical utility.

Various suggestions have been made for simplifying these procedures, which must be mentioned without entering into details, in the hope that they may serve as hints to other surgeons who are working at the subject. Such are the production of high pressure after intubation, or the employment of a mask fitting tightly over the patient's face, or the administration of the anæsthetic vapour into a chamber like Brauer's without the hands of the anæsthetist, each of which appears to introduce some advantages, but perhaps an equal number of drawbacks.

The difference in pressure required is not large, on the average about 3–10 millimetres of mercury.

Indications. Having now discussed the methods by which thoracotomy can be practised without the production of pneumothorax, it remains to consider what cases are likely to be benefited by it.

(i) If it were felt that an extensive opening into the chest could be made without immediate danger or prospective disability, surgeons would feel justified in making exploratory openings as they make exploratory laparotomies where the presence of foreign bodies or possibly removable malignant tumours was suggested by the history, by the symptoms, or by radiography. The lung could be methodically handled all over, and it is conceivable that in the future growths may be more early diagnosed or completely removed. One reads about the removal of a tuberculous lobe of the lung, or a portion of a lung which is affected by limited bronchiectasis. One also hears about these operations being carried out antiseptically, but not having personal experience of such procedures I hesitate for the present to express an opinion as to the advisability or the feasibility of their performance. For the same reason I do not feel justified in attempting to describe the best way of dealing with the stump after pneumectomy, or the best position for the opening under different circumstances. Those who contemplate performing such operations would no doubt desire to consult the copious discussions which have taken place at the German Surgical Congress of 1907 and 1908, which may be found in their own special reports, or in less detail in the *Centralblatt für Chirurgie*.

(ii) Mediastinal growths and malignant tumours of the œsophagus have also been dealt with by these methods, but so far apparently with but little if any success.

(iii) The prevention of pneumothorax would be of great assistance to the surgeon in dealing with tumours of the chest-wall, and I think might

sometimes be the means of avoiding danger to the patient when it is necessary to traverse the healthy pleura in opening a septic abscess—say a liver abscess—below the diaphragm.

(iv) Some very interesting cases have been reported of the employment of these methods in cases of wounds of the heart. The production of a pneumothorax diminishes the blood pressure, and, experimentally at all events, it appears to be possible in this way to limit the possible contraction of the heart muscle while the sutures are being inserted, and afterwards by doing away with the pneumothorax and closing the chest to allow things to return to their normal condition.

Before leaving this subject it is proper to mention a development of it which has been used for the purpose of drawing out the lung in the treatment of empyema. A tightly fitting india-rubber box is attached to the patient's side in which the air is exhausted to the desired amount, and in which some arrangement is made for the reception of the discharge. It is said that this can be made of such a size that the patient can wear it under his clothes, and that it has been found of real value in diminishing the time of closure of an empyema.

OPERATIONS FOR SEROUS EFFUSIONS

The time for drawing off a serous effusion must be determined by the physician; but I have never known harm to be caused by the removal of a small collection of fluid, and have often seen improvement follow on its performance.

Two *instruments* are available for the purpose: one, the *bottle aspirator* referred to above (see p. 701), and the other a needle like that employed with the aspirator, to which is attached a piece of india-rubber tube long enough to pass into a vessel placed upon the floor; this should be compressible by means of a clip, and weighted at the distal end. This is a very simple, inexpensive, easily cleanable, and efficient apparatus (Fig. 362). The negative pressure obtainable is sufficient for most, if not all cases. A simple perforated needle may be substituted for the more complicated one recommended; but it is possible to wound the lung with it.

Position of patient. If the effusion be a large one there is no advantage, but, on the contrary, there are serious disadvantages and some risk in sitting the patient up and puncturing behind. He should lie flat on his back in a comfortable position, not too close to the edge of the bed, and the needle should be passed through the lower part of a convenient intercostal space, say the sixth or seventh, in the mid-axillary line. Here the spaces are wide, the amount of tissue to traverse small, and there is no danger

of striking a rib with the needle. If the needle be sharp and introduced with decision, the pain is trifling, but any form of local analgesia (except freezing the skin hard) is admissible. The needle should be long enough to reach the angles of the ribs and the posterior part of the pleural sinus. It is needless to say that gravity has nothing to do with the process of evacuation by aspiration; the only essentials are that the end of the needle should be free in the fluid, and not obstructed by having lymph or lung sucked against the openings.

The fluid should be extracted very slowly, the pump of the aspirator being just kept at work, producing the smallest possible negative pressure in the bottle. A complete vacuum is likely to draw lymph or lung against or into the openings, and a rapid removal of the fluid is less safe and less comfortable for the patient than a slow one. It also causes a minor inconvenience, *i.e.* more frothing of the fluid.

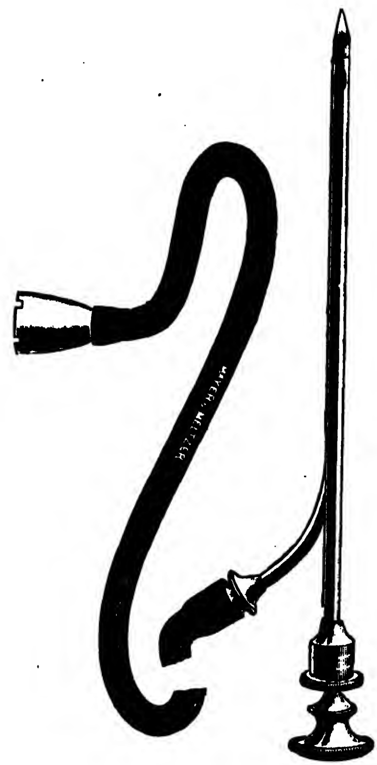


Fig. 362. A Simple Siphon Arrangement. ¾ scale.

It is not possible to remove the whole of the fluid except under the improbable circumstances of the lung and chest-walls being quite normal. Usually a time comes when a distressing and ungovernable desire to cough attacks the patient. When this occurs, the process should be stopped for a while and a piece of ice given him to suck. If the cough passes away, more fluid may be withdrawn. If not, the needle should be removed; the discomfort will probably not last more than half an hour. Another reason for stopping is the staining of the fluid with blood; this may occur in any case, and is usually of no consequence, but I have known it lead to fatal internal hæmorrhage in a case of malignant disease.

Substitution of air and other fluids for the serum. It is no new suggestion that a complete removal of the fluid can be effected by the substitution of atmospheric air, that this adds no danger if the air be filtered, and that a negative pressure can be left within the chest by withdrawing any excess of air that may have entered. I have no personal experience of this method, and the reader is therefore referred to the animated discus-

sions on this subject in the medical press; but I would remind those about to practise it that it does not follcw, because air is rapidly absorbed by the healthy pleura in a traumatic pneumothorax, that it will be as satisfactorily dealt with by the unhealthy serous membrane of pleurisy; the behaviour of cases of tuberculous pneumothorax indeed would make one expect that the air would not be readily absorbed.

The treatment of chronic serous effusions has also given rise to much discussion. I will first deal with those in which repeated examination does not reveal the presence of tubercle, and in which the cause is therefore obscure. I have obtained good results from repeated tapping, the intervals varying from days to weeks or months in accordance with the rapidity of reaccumulation of the fluid. The injection of adrenalin or of substances like tincture of iodine in small quantities has been recommended, and if the fluid injected is aseptic or antiseptic, it is probably a safe procedure. A free opening into the chest and the introduction of a drainage tube has also been advised, but, though successful cases have been reported, I am convinced that it is a dangerous practice, and one that is liable to be followed by that incurable condition—a collapsed lung in the centre of a complete septic pneumothorax with an external opening.

In tuberculous cases I have obtained a moderate degree of success, but, it must be owned, no brilliant results, by inserting through an anterior intercostal space at the time of aspiration a second needle made to communicate by means of an india-rubber tube with a vessel containing boric acid lotion or normal saline solution. After prolonged irrigation the excess of fluid was drawn off by the aspirator. The success of this treatment, if it succeeds, must be open to the same explanations as are offered for the successful treatment of tuberculous ascites by incision with or without irrigation or sponging, amongst which that of Sir Almroth Wright at present holds the field.

OPERATIONS FOR EMPYEMA

The proper line of treatment depends upon whether the affection is complete or localized, upon the age and state of the patient, upon whether it is unilateral or on both sides, and a variety of other conditions which will appear in the sequel. Except in double empyema no delay in evacuating the pus is admissible.

Aspiration. Experience shows that occasionally in adults and frequently in children aspiration of an empyema, especially if repeated on two or three occasions—say, with the interval of a week—is followed by a cure. But this result cannot always be obtained, whereas a free incision in children is usually a successful operation and is followed by rapid healing.

Speaking generally, the more quickly a cure can be effected, the better it will be for the lung, and therefore, considering the frequency with which it is not successful, aspiration cannot be recommended; though there are certain cases, such as double empyema, in which it may be advisable.

COMPLETE UNILATERAL EMPYEMA

This condition is seldom met with except when the sudden rupture of an abscess occurs into a previously normal pleura. In almost all other circumstances some part of the cavity is obliterated by adhesions: either the base of the lung is adherent to the diaphragm, or the inner surface to the mediastinum, or the back of it to the angles of the ribs, or the pleural sinus is obliterated, or patches of adhesions exist in other parts; but for practical purposes an empyema may be spoken of as complete when the whole of the chest-wall is available for the incision. A really complete empyema must be immediately evacuated in order to save life. If the lung be healthy and completely collapsed, the ultimate outlook is bad, and subsequent Estlander's operations (thoracoplastics) will probably be necessary. In such cases the apparatus mentioned on p. 708, in the section on 'high-pressure' and 'low-pressure' operations, seems to offer a chance of drawing the lung out to the chest-wall, and should certainly if possible be employed.

Much has been written about *the most favourable position to select for the incision*, and arguments have been brought forward in favour of lateral incisions which to me are unconvincing. I have no hesitation in recommending a posterior opening both on theoretical grounds and as the result of experience, the best place being, in my opinion, the region of the ninth or tenth rib, not far from the scapular line. I have often had to make a posterior incision when a lateral one has failed to effect a cure, but never to make a lateral one when a posterior one has proved inefficient. An incision in the spot recommended will usually be found to be almost, if not quite, at the lowest part of the cavity, because the diaphragm has become adherent to the chest-walls before the effusion took place; and if it be not at the time actually the lowest part, it soon becomes so owing to the extension of this process. If a lower spot be chosen, the opening usually becomes valvular. The posterior incision ensures the best possible drainage both when the patient is recumbent and when the body is raised, and the theoretical objection that lying on the incision may be a source of much discomfort to the patient is not supported by experience.

The question of the advisability of removing a portion of rib has been the subject of prolonged but not very illuminating discussion. It cannot be denied that many cases may recover without interfering with a rib,

that in a lateral incision the spaces may be so wide that it is not essential, that sometimes the patient is in so bad a state that any prolongation of the operation is a drawback, and that in very septic cases the risk of secondary hæmorrhage is increased; in the vast majority of cases, however, the slight prolongation of the operation is of no consequence, the large size of the opening obtained is of immediate advantage in enabling the surgeon to thoroughly explore the pleura, open up outlying pockets, and remove masses of lymph, and in the subsequent treatment, the pain caused by the contraction of the wound upon the drainage tube is prevented. In very septic cases the risk of secondary hæmorrhage may be minimized by dividing the intercostal artery and tying it in two places. I therefore recommend as a routine practice the removal of about 3 inches of one or, if necessary, two ribs.

Operation. If the pleura be much distended it is well to draw off the greater portion of the pus with the aspirator before beginning the operation, sometimes before the administration of the anæsthetic.

FIG. 363. PERIOSTEUM ELEVATOR SUITABLE FOR CLEARING THE RIB. ½ scale.

The patient should be placed on a high table with the affected side projecting rather beyond the edge of it, turned very little over on to his sound side. It is dangerous to turn him much on to the sound side, especially if there be much fluid or if the empyema has ruptured into a bronchus. The operator should sit if the table be a low one. If the condition of the patient be very bad, he may be placed upon the diseased side near the middle of the table, and the surgeon, in this case standing up, may operate from behind.

If a general anæsthetic be employed, chloroform or chloroform and oxygen is usually the safest. The anæsthesia should not be so deep as to abolish the laryngeal reflex, and the surgeon should remind the anæsthetist that slight movements will not seriously impede the operation. Local analgesia produced by the injection of eucaine may be substituted for general anæsthesia if desired, and will probably be quite efficient. Freezing of the part, however, is satisfactory neither to the patient nor the surgeon.

I always now employ a *vertical* incision (see Fig. 364), and have discarded the oblique or transverse one. The latter involves a transverse division of the fibres of the latissimus dorsi, and unless great care be taken that the skin be not drawn up by raising the arm, is often found to be lower than the opening in the chest-wall when the operation is completed.

Should the oblique incision have been selected, and this accident occur, it must be rectified by converting the incision into a ⊥-shaped one, as it is essential that the superficial and deep openings be opposite to one another. The vertical incision should be 3½ or 4 inches long, and should be followed by splitting the latissimus in the direction of its fibres for

FIG. 364. VERTICAL INCISION FOR EMPYEMA. L.D., Latissimus dorsi S.P.I., Serratus posticus inferior; x, Rib.

an equal distance and then dividing the serratus posticus inferior across the direction of its fibres. The parts are then held widely apart by long retractors and the periosteum of the rib thus exposed divided for 3 or 4 inches. The periosteum is then separated from the rib by a blunt, slightly curved periosteum elevator (see Fig. 363) both on the superficial and deep surfaces, and the rib divided as far forwards and backwards as possible, the retractors being placed first forwards and upwards and then backwards and upwards as shown in Fig. 365.

Many special forceps and scissors have been invented for the purpose, which do not appear to me to be better than an ordinary pair of curved bone-forceps.

After the removal of the piece of rib any bleeding vessels are secured and, if it be thought advisable, the intercostal artery is divided and ligatured. The nerve should, if possible, be preserved, because, although its preserva-

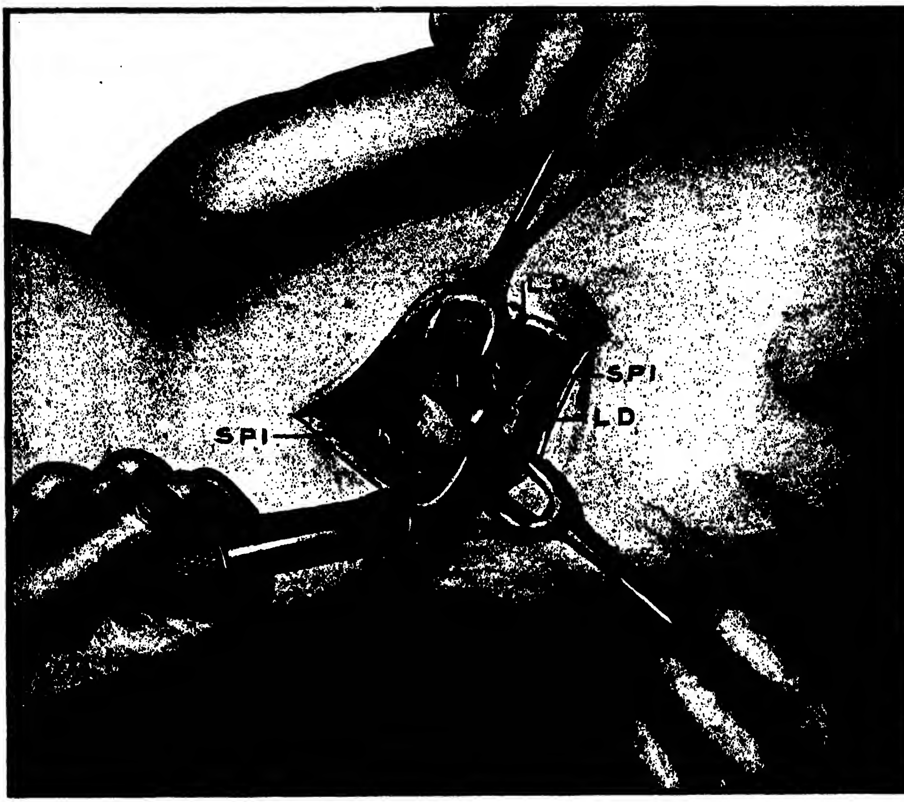


FIG. 365. SECOND STAGE OF THE OPERATION FOR EMPYEMA. L.D., Latissimus dorsi; S.P.I., Serratus posticus inferior; E.I., External intercostal muscle; X, Rib.

tion sometimes is followed by neuralgic pain owing to the pressure on it by the tube, its division is sure to cause a patch of numbness in the area it supplies. The pleura is then opened either by the knife or a pair of dressing-forceps, and the gloved finger is at once inserted into the wound, partly for the sake of estimating the state of the lung before the fluid has escaped, and partly because it is advisable, if the amount of fluid be large, to allow it to escape gradually in order to avoid the shock that may result from its too sudden evacuation. After the fluid has

escaped the state of the lung is again examined, and for this purpose, in my opinion, the most dexterous use of the probe is inferior to that of the finger. Lymph is extracted, and a search is made for pockets or secondary cavities which require opening up, or unusual conditions such as openings into lung or liver, carious bone, calcareous plates, the contents of a dermoid cyst, &c., and then the tube is inserted.

At this stage two large tubes, ½ to ⅝ inch in diameter, just long enough to project about 1 inch into the pleural cavity, and each provided with one large hole close to the proximal end, should be employed, and all anxiety about their slipping in or out may be avoided by stitching them with two strong fishing-gut sutures to the skin after cutting the ends nearly flush with the surface of the skin. The only occasions in which long tubes are required are those of long cavities, the distal narrow part of which only has been reached by the incision. The calibre of the tubes, of course, may be regulated by the size of the cavity and the nature of the contents. Very free drainage is required for large stinking cavities, much less for small cavities, the contents of which are not greatly septic. Though I find two tubes convenient, I have no quarrel with those who prefer a single tube. There is no need to interfere with these tubes till a week after the operation, when a single flanged tube may be substituted for them (see Fig. 366). Smaller tubes may be used in the case of children, and in them, or when the cavity is small, the use of two tubes at first is not essential; but what is important in all cases is to secure absolutely free drainage during all stages of the treatment. A short tube, the length of the

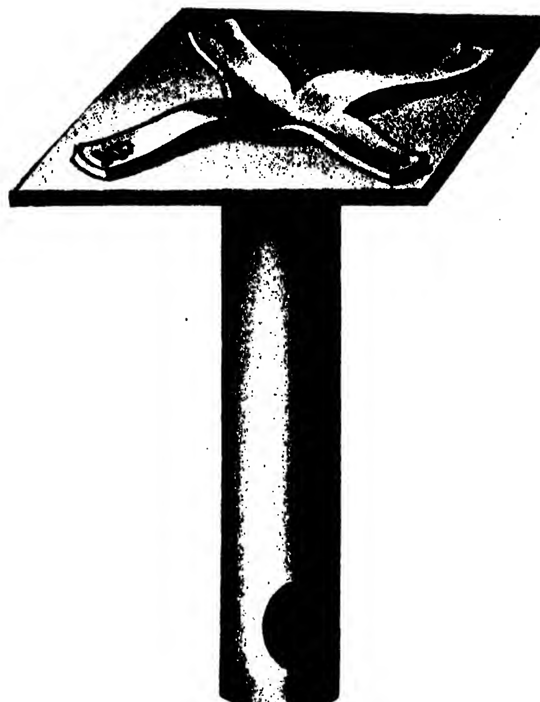


FIG. 366. FLANGED TUBE. The flange is attached with twisted silver wire; observe the position of the hole.

thickness of the chest-wall, provided with a flange at each end so that it can slip neither in nor out, is recommended by Mr. Bilton Pollard (see Fig. 367).

As a general rule, it is wise to use antiseptic dressings, but when the pus is foul it is more satisfactory, at all events for a time, to apply boric fomentations and to change them frequently. The mortality from operations on empyema has notably diminished since very free drainage has been aimed at and the introduction of the antiseptic treatment ; but it must be remembered that the successful antiseptic management of such large discharging cavities demands great care and attention.

After-treatment. The length of time that the tube is to be retained depends upon the amount of discharge and the rapidity of the closure of the cavity. In children it may often be removed at the end of ten days, though it will often be necessary to drain for a much longer time. In adults it is seldom possible to remove it before six weeks, though I have known empyemata close in three weeks even in people of advanced age.

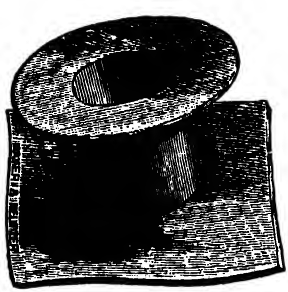


FIG. 367. MR. BILTON POLLARD'S EMPYEMA TUBE.

Occasionally it may be possible, if the discharge be very slight, to remove the tube even while a considerable cavity remains. In such a case the final closure is brought about by the absorption of the air which occupies the cavity after the external wound has closed. If this method be adopted it is wise to introduce a railroad catheter at intervals of a few days. If the fluid that escapes be clear serum and small in amount, it is safe to continue with this line of treatment; if, however, the fluid be pus, the tube should again be inserted for a time.

Cases that are doing well may leave their beds at the end of a week or ten days. They often do better when the erect posture is assumed than while recumbent.

Chest exercises, such as blowing into a bottle, are often useful. It is only by forced expiratory efforts while the glottis is closed that actual mechanical inflation of the collapsed lung can be brought about, though no doubt the function of the affected lung may be improved by forced respiratory movements if considerable adhesions of the lung to the chest-wall have taken place. Suggestions for drawing out the lung by atmospheric pressure are mentioned at p. 708.

If an empyema be unopened it may point through any one of the intercostal spaces. The commonest is the fifth, just external to the origin of the pectoralis major, but I have seen rupture occur through all

the spaces and at any part. I have followed a track down to the first intercostal space in the axilla. Sometimes an empyema may rupture into the pericardium or passing through the diaphragm point at the lower part of the abdomen. It is said that one has at last entered the thigh and pointed at the ankle. It is not safe therefore to assume in any given case that it is not one of empyema because the orifice of the sinus is at some distance from the supposed seat of the mischief.

DOUBLE EMPYEMA

Both sides of the chest have been opened at the same time without evil consequences; but this course is not to be recommended, because of the uncertainty as to the presence or absence of adhesions. No doubt adhesions are usually present on both sides, and thus the double incision is usually safe because both lungs can be expanded by expansion of the chest walls. But the free opening of both sides of a normal chest would be certainly fatal, and on one occasion it is stated that the accidental opening of the wrong, that is, the healthy side, in a case of empyema was followed by a fatal result. The wise course, in my opinion, therefore, is to open one side freely and to aspirate the other. As was pointed out above, aspiration sometimes leads to the cure of an empyema, especially if repeated on two or three occasions. I have several times obtained this result in double empyema in children, but if after a certain time, when the patient is accustomed to the altered respiratory conditions, the pus continues to accumulate in the unopened side, and the lung on the other side is obviously doing some work, it is best to open the second pleural cavity and drain it.

CHRONIC EMPYEMA

There are several reasons why an empyema may become chronic, and which must modify opinion as to the advisability and nature of the treatment. Amongst them are to be noted :—

1. An opening badly situated or insufficient in size.

2. The large size of the cavity, which, though to some extent obliterated by adhesions, is not capable of further reduction because the limits of contraction of the walls and expansion of the lung have been reached.

3. The complete collapse of the lung before any pleural adhesions have formed, such as occurs after wounds of the thorax or from the sudden rupture of an abscess or a hydatid into a healthy pleura.

4. The presence of a bronchial or biliary fistula.

5. Tuberculous disease which is sometimes associated with the formation of larger or smaller calcareous masses or plates.

6. Malignant disease of the pleura, which is sometimes not suspected at the time of the operation.

7. The presence of foreign bodies.

1. *If the opening be insufficient or badly placed,* pus will be retained in the cavity, and in the latter case can be emptied out at the dressing. If the opening be well placed but too small it should be enlarged by removing part of another rib, probably that above the original opening. If it be badly placed a second opening must be made in a more favourable position, the proper place for which may usually be determined by introducing the finger and thus ascertaining the lowest part of the cavity both in the recumbent and the erect postures.

2 and 3. *If the cavity be too large to close by natural processes,* the desired end may sometimes be attained by removing the rigid parts of the chest-wall. This is what is known as thoracoplasty or Estlander's operation, so called after the Swedish surgeon who devised it. The ideal operation is to remove first all the portions of rib which constitute the framework of the outer wall of the cavity, and subsequently to take away the periosteum and pleura for a corresponding extent, thus still further reducing the rigidity of the chest-wall (for the pleura will be probably an inch thick), and doing away with the chance of the extensive formation of new bone. It is, however, obvious that in those cases where no adhesions are present this ideal operation is impossible, and even when the condition is not so extreme, but still the cavity is very large, it will sometimes be enough to remove large portions of ribs from the front and sides of the chest and to supplement this by dividing the ribs near their angles through small incisions. It is easy to divide three ribs through one small incision over one of them, pulling it upwards and downwards for the ribs above and below the one first dealt with.

Thoracoplasty. It is neither necessary nor advisable to give precise instructions as to the performance of a thoracoplasty, because the procedure varies with the size and extent of the cavity, but some practical points may be set out. The shape and size of the cavity are first ascertained with the finger or the probe (see Fig. 368), and then the position of the incision is so planned as to afford easy access to the ribs it is desired to remove, and at the same time it should be devised so as to avoid dividing transversely muscles with the use of which it is not proposed to interfere. Thus it is often advisable to make it curved or angular; sometimes two incisions are preferable to one. The exposure of the ribs should be quickly carried out because the operation is often a severe one, and the hæmorrhage is sometimes considerable. It seems as if, owing to the fact that the intercostal trunks themselves are generally so far obliterated by the contraction of the surrounding fibrous tissue as not to require the applica-

tion of a ligature if divided, the superficial circulation is abnormally free. The ribs should be removed in the usual way, *i.e.* after separating the periosteum, because the periosteum is more easily and rapidly taken away afterwards with the thickened pleura with which it has become incorporated. The surgeon should not hesitate to remove six, seven, eight, or more inches of each rib, but he should recollect that it is not essential to finish the operation on one occasion. The attempt to do so has sometimes caused a fatal result. It is a good plan in bad cases to

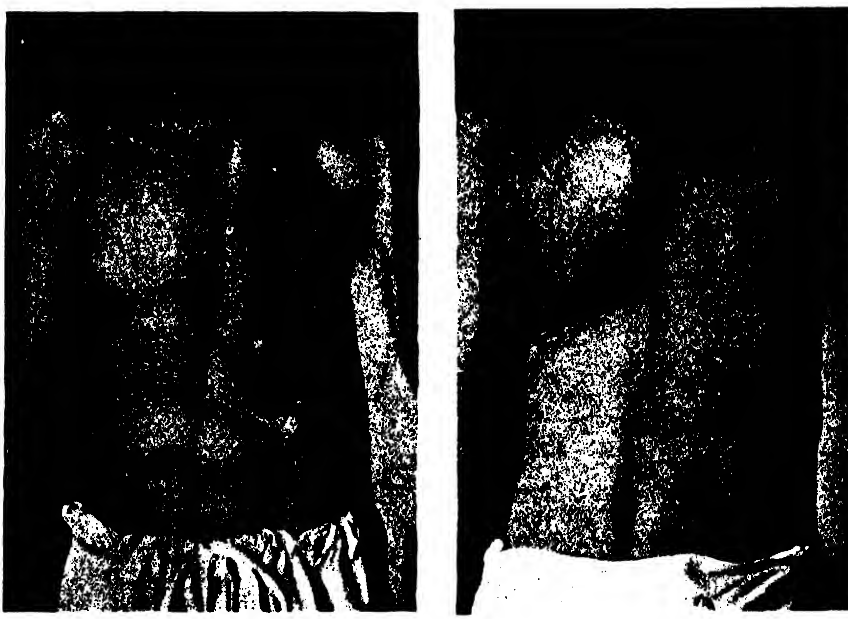


FIG. 368. FRONT AND BACK VIEW OF AN OLD EMPYEMA. From a photograph taken before the operation. The dotted line in the back view shows the extent of the cavity as ascertained during the operation.

perform the operation in two or even more stages, allowing some weeks or months to elapse between them. I have indeed known what at the time was supposed to be an incomplete operation result in a cure. The appearance seen in the completed operation on the patient shown in Fig. 368 is shown at Fig. 369, which is taken from a photograph. The most difficult part of the pleura to close is that included in the rigid circle of the upper two or three ribs. I would again point out how simple a matter it is to attack the first and second ribs from behind, and how difficult the first rib is to deal with from the front.

When the time comes for removal of the periosteum and pleura, this may usually be done freely with knife or scissors without fear of bleeding

from the intercostal arteries, which, as has been said, are either obliterated or much smaller than normal.

I have never myself seen any harm come from applying strong lotions (say chloride of zinc 40 grs. to water ℥i) to the pleura before closing the skin wound; but I have heard of a death apparently arising from a similar cause. Some caution should therefore be observed in irrigating the remains of the cavity.

FIG. 369. COMPLETED THORACOPLASTY ON THE PATIENT SHOWN IN FIG. 368. From a photograph taken before inserting the stitches.

I think it is important to keep a drainage tube of large size in the *upper* as well as the lower part of the incision.

It is seldom advisable to remove such ribs as are in contact with the pericardium. It can of course be done without killing the patient, but the obvious pulsations of the heart under the skin are a source of considerable discomfort, and it seems likely that the exposure of this organ to possible injury is not altogether free from danger.

4. *Biliary fistulæ* may follow the opening of hydatids or abscesses of the liver which have burst into the lung and been followed by empyemata. They are not very uncommon. As long as the bile is discharged freely, there is, as far as I have seen, no chance of the empyema closing, however

much it be reduced in size, and no operation on the empyema is likely to be of use. Such cases, however, usually get well at last owing to the closure of the bile duct in the liver, though the bile may flow for months and the patient may be reduced to the last stage of emaciation. If *all* the bile escape by this channel owing to obstruction of the common bile duct, it may be necessary to unite the gall-bladder with the intestine. In cases of amœboid dysentery followed by abscess a sloughing process may cause the cavity actually to increase in size, and this ulcerating process may extend into the lung as well.

The presence of a *bronchial fistula* may also permanently prevent the closure of an empyema, though this I think depends to some extent upon the state of the lung or bronchi. For example, if bronchiectasis be present, the amount of mucus discharged into the pleura is enough to prevent its closing, and the same may be said of tubercle or malignant disease. If, however, the lung be healthy, in the great majority of cases the opening in it closes, and the empyema follows the usual course towards a cure. No special treatment for it is demanded or available.

5. *The presence of tuberculous disease* usually, though not invariably, prevents the closure of an empyema, even if the shape and size of the cavity are such as are favourable for a cure. If the patient be in good general condition and the cavity be of moderate size, thoracoplasty should be attempted after warning the patient that the result would probably though not certainly be unsuccessful. But if the tuberculous process be active or advanced, and the cavity be large, it is not right to diminish the patient's vitality by what is sure to be a useless procedure. If calcareous plates be met with, they should be removed if not too large, but not until the external opening is very free, because they are sometimes in contact with large vessels which may be torn during the process of extraction. An abscess originating in caries of the spine, sternum, or rib, or a tuberculous mediastinal gland may, by bursting into the pleura, give rise to an empyema which can only close after the cure of the primary disease by natural or artificial means.

Whenever tuberculous disease is present every effort should be made to improve or cure it before undertaking any serious operation.

6. No treatment is likely to do any good if *malignant disease* be present.

7. *Foreign bodies*, such as drainage tubes, bullets, pieces of wool, portions of necrosed rib, ears of corn, &c., will effectually prevent the closure of an empyema and call for immediate removal. I have known a lead pencil to be driven through an intercostal space into the lung and remain unsuspected until an incision revealed its presence.

Actinomycosis and dermoid cysts will be dealt with separately.

OPERATIONS FOR CHYLOTHORAX

Chylothorax may be caused by wounds of the thoracic duct or by rupture of this vessel owing to obstruction in filarial disease or in connexion with malignant disease. The traumatic cases may be those of wounds, or of fracture of the vertebræ. True chylothorax must not be confused with the milky pleural effusions met with in some cases of malignant disease. In cases of traumatic rupture of a previously normal thoracic duct healing may be expected to occur after a longer or shorter period of time, as happens almost always if the duct is injured in the neck. If the rupture be complete it is probable that the establishment of anastomosing channels favours this result. In all cases of milky effusion into the chest, therefore, no surgical interference is indicated except it be removal of the fluid by aspiration, and that only if the accumulation is large and leads to interference with the respiration. It may have to be repeated several times. In malignant cases the reaccumulation sometimes occurs very quickly, and under these circumstances little or nothing is gained by aspiration.

CHAPTER IV

OPERATIONS UPON THE LUNGS

OPERATION FOR ABSCESS OF THE LUNG

The method of operating upon, that is of opening, all cases of abscess of the lung is the same, but as the chance of doing good varies very much with the nature of the abscess, it is necessary shortly to discuss the conditions that may give rise to a pulmonary abscess.

Abscess of the lung may be acute or chronic, circumscribed or diffuse.

Indications. Amongst acute abscesses are those resulting from acute pneumonia, septic emboli, the presence of rough foreign bodies, the rupture into the lung of abscesses from neighbouring parts, and some tuberculous abscesses. In all of these except those that occur as a part of a general embolic pyæmia, there is a possibility of affording relief by evacuating the contents.

Chronic or subacute abscesses may result from pneumonia, tubercle, tumour, from the presence of smooth foreign bodies, from the gradual extension of chronic abscesses from surrounding parts, and from bronchiectasis. It is always doubtful if any good will come of opening cavities resulting from tubercle or tumour. Those resulting from tumour are not usually diagnosed before operation, sometimes, indeed, not till long afterwards. Chronic tubercular abscesses, if occurring at the base of the lung, are often much benefited by incision, but they seldom heal. The question of bronchiectasis must be dealt with separately.

Diffuse suppuration of the lung, whether resulting from acute pneumonia, pressure on a bronchus, or tubercle, does not form a favourable field for surgery, though I have known much benefit, it might be said cure, result from incision of acute diffuse suppuration of the base of the lung in a patient supposed to be tuberculous.

Operation. If it be decided to operate, the first thing is to ascertain the position of the abscess by means of the aspirator. It is seldom wise to open the chest until this has been done, and it must be remembered that all the signs of abscess may exist though no localized collection of pus be present. Under no circumstances should an exploration be made by a simple exploring trochar, as it is impossible to diagnose with certainty the presence of adhesions, and if air be admitted to the pleura, the position of the abscess is likely to be altered.

Having ascertained the presence of an abscess the trochar may be retained as a guide, though it impedes the subsequent steps of the operation, or the surgeon may withdraw the trochar and trust to his memory for finding the abscess after dealing with the chest-wall.

Three or four inches of two or more ribs are then removed in the usual way, but much greater care must be taken in clearing the deep surfaces of the ribs than in a case of empyema, as there is danger of opening the pleura and, by causing a pneumothorax, preventing the successful completion of the operation. When a sufficiently wide area of the costal pleura is clearly exposed, a single or preferably double row of continuous catgut sutures is inserted by means of a rather large fully curved Hagedorn's needle, which is passed deeply enough to attach the lung to the chest-wall, and, if any air is heard to suck into the pleura, more stitches should be inserted until the union is definitely air-tight. When this result has been obtained, the pleura is to be incised, and then the abscess is again sought for with an ordinary exploring trochar, or if the original trochar has been retained in position, this will serve as a guide. The actual opening of the abscess is conveniently done by means of sinus forceps or dressing forceps, or even by the knife. I do not recommend the use of Paquelin's cautery, as the hæmorrhage is seldom of much moment and usually stops after a few minutes' pressure, even if, as happens in some cases, it is at first rather severe. The finger then follows the instrument with which the opening has been made, explores the cavity, breaks down obstructing bands, and then a drainage tube, of suitable length to thoroughly drain the cavity, is inserted and fixed in position to the skin as in a case of empyema. If bleeding be free, the tube may be packed round with gauze, though this should, if possible, be avoided as it may cause unnecessary damage to the lung.

If unopened, pulmonary abscesses may burst externally, sometimes just above the clavicle or sternum, occasionally involving on their way the sterno-clavicular articulation, or through an intercostal space, or passing into the abdomen may reach unsuspected regions

OPERATIONS FOR BRONCHIECTASIS

When giving an opinion about the treatment of a case of bronchiectasis it is necessary to inquire into the cause and history of the case. The most hopeless ones are those that come on insidiously as the result of, say, whooping-cough or pleurisy or chronic bronchitis, and already yield physical signs at both bases; the more promising are those that follow the inspiration of foreign bodies, or those that result from some localized pulmonary affection even if it be tuberculous.

The results of surgical interference have been so unsatisfactory that

one is often tempted to refuse operation. If there be extensive dilatation of bronchi on one or both sides (see Fig. 370) the mere opening and draining of one cavity, which is often a simple enough matter, can hardly give more than a temporary relief. The most reasonable surgical procedure would be an extensive horizontal section of the lung which might open many of the cavities. It would have to be made with the actual cautery and might involve serious bleeding. The removal of many ribs in order to allow the chest to fall in, with the idea that any further contraction of the lung might involve a diminution in the size of the bronchi, has more theoretical than practical value.

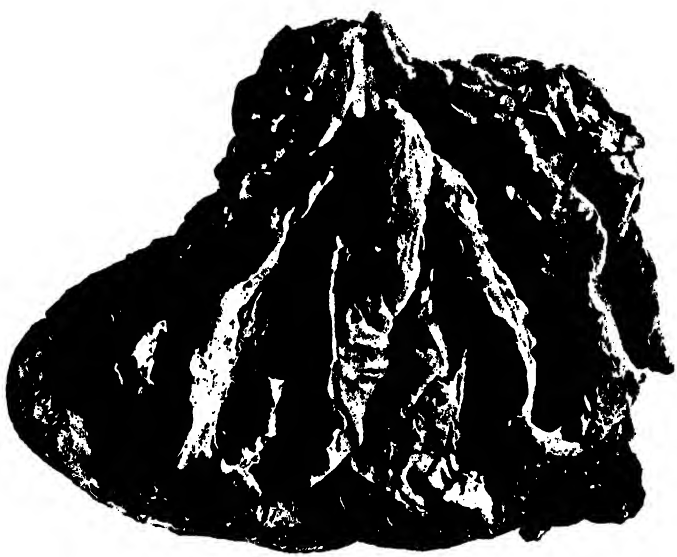


FIG. 370. MUCH-BRANCHED BRONCHIECTASIS, UNFAVOURABLE FOR OPERATION.

But it must be remembered that the process is not necessarily so widespread as the physical signs suggest, and also that there may be one cavity resulting from the fusion of several bronchiectases. In some of these localized cases large portions of the affected lung have been removed, apparently with good effect. Occasionally, after giving little or no hope of benefit, I have found such a cavity (see Fig. 371) and cured the patient by free incision into the lung (see Fig. 372); but I have often seen operations followed by temporary benefit and later on by a relapse, accompanied perhaps by severe hæmorrhage or cerebral abscess or some of the other recognized sequelæ of bronchiectasis. The condition is, however, so hopeless if untreated, and so extremely disagreeable, that patients often grasp at the slender hope of cure which operation offers, and then the

surgeon is justified in undertaking it. I desire to emphasize the fact that even in advanced cases, and in spite of suggestive physical signs, it is common to meet with a completely non-adherent pleura.

FIG. 371. LARGE CAVITY RESULTING FROM BRONCHIECTASIS, FAVOURABLE FOR OPERATION.

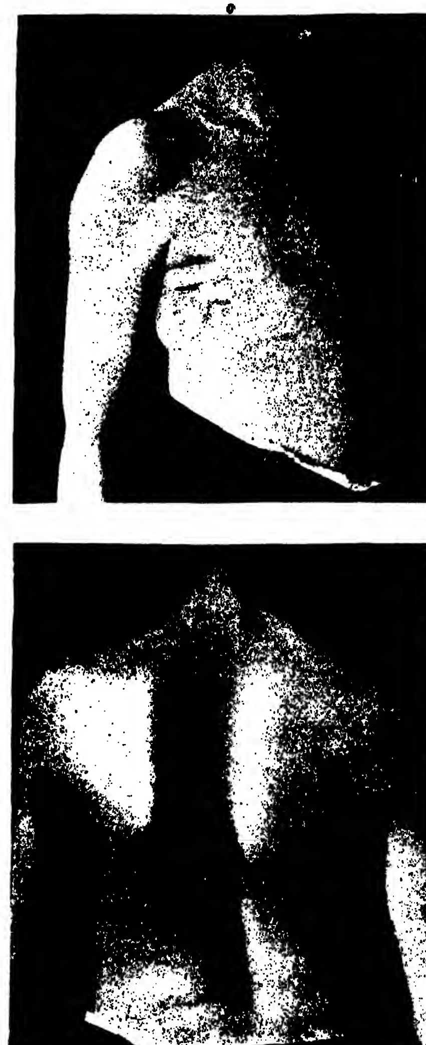


FIG. 372. LATERAL AND BACK VIEWS OF A BOY WHOSE BRONCHIECTATIC CAVITY WAS CURED BY OPERATION.

The exploratory puncture of a lung riddled with dilated bronchi and yielding marked physical signs of a cavity and copious expectoration often fails to extract even a drop of pus. Should, however, a cavity be reached and opened its nature is at once recognized on introducing the finger by the smooth lining wall, which contrasts with the spongy wall of most other pulmonary cavities. Very copious and even dangerous hæmorrhage may occur if any attempt be made to dilate the neck of such a cavity; this

may also occur apparently from ulceration caused by the drainage tube at a subsequent period, or from the puncture made before the operation for the sake of diagnosis. Such hæmorrhage can be stopped by plugging, as the walls of the cavity are firm, but is very apt to recur, and, as is known, is quite common if no surgical treatment has been adopted.

It is specially after opening a bronchiectasis, though it is observed in other cases of pulmonary abscess, that a loud whiffing sound is heard on inspiration and sometimes a louder sound on expiration. Respiration through the opening is indeed often so free that the patient can breathe with mouth and nose shut, and cannot speak above a whisper unless the wound be closed. This inconvenience may be overcome in cases where it is desirable to keep the opening patent as a matter of precaution, and when the discharge is little or nothing, by substituting a solid plug for the tube and removing it when required; or if a tube is still necessary, by keeping the dressing in place by strips of adhesive plaster. If the case is thought to be cured the opening should be closed by a plastic operation.

OPERATION FOR TUBERCULOUS ABSCESSES

Chronic tuberculous abscesses at the base should always be opened, and though in some cases a permanent fistula may result, a certain number will be cured. Cavities at the apex are usually only a part of extensive pulmonary infiltration and are probably in most cases better left alone. But I think there must be a certain number in which the disease is localized where an incision into a dependent part would, by relieving cough, make the patient more comfortable and possibly check the advance of the disease. This view has not, however, made much way with physicians, certainly not in this country, probably because the suitable cases are just those in which a spontaneous cure may be anticipated, and also because a phthisical patient with a large apical cavity is not nearly so much troubled by the cough and expectoration as one who has an imperfectly drained basic cavity or a bronchiectasis; the cough of a phthisical patient being comparatively speaking an easy one and the sputum never having the foul smell that is common in that of the other cavities referred to. But I still think, as I said long ago, that this is a field of surgery which is capable of further development.

Operation on tuberculous cavities is usually rendered simple by the presence of adhesions. The surgeon will sometimes be disappointed by finding, both in the more acute and the more chronic cases, that instead of the large cavity which the physical signs have appeared to indicate, the whole of the affected part of the lung is riddled with small

abscesses. Operation in such cases may, however, be followed by beneficial results.

Amongst the surgical treatment of tuberculous cavities must be mentioned the *intrapulmonary injection* of various medicaments which has from time to time been suggested. The method of performing this little operation does not call for a detailed description.

On different grounds it seems unnecessary to describe the suggested operations for *removal of the affected part of the lung*. It has been shown to be possible both in the lower animals and in man ; but as it is a treatment only applicable to early cases for which more rational and more hopeful treatment is available I cannot believe that 'extirpation of the lung' for tuberculous disease will find a permanent place amongst recognized surgical operations.

REMOVAL OF FOREIGN BODIES IN THE LUNG

The removal of foreign bodies from the bronchi by means of the bronchoscope is dealt with in Vol. IV. The attempt to extract foreign bodies from the lung itself may fall to the lot of the general surgeon.

Smooth bodies may remain for months or years in one of the smaller bronchi, gradually setting up bronchiectasis, but not creating a cavity in their immediate neighbourhood. Rough ones may set up ulceration at the points where they are lodged; such objects as pieces of grass may travel to distant parts of the body and possibly escape from the surface, while seeds may swell or germinate. Any of them may cause irreparable damage even after a short residence in the lung, and therefore, if possible, an attempt should be made to remove them without delay. If they are opaque to X-rays a stereoscopic skiagram should be taken and the precise distance from the surface of the body should if possible be ascertained.

Operation. It is presumed that trachectomy has been done and that the approved methods of extracting the foreign body from above have been practised. If these have proved unsuccessful the chest must be freely opened; and either the lung must be fixed to the chest-wall as described (see p. 724), or if available the methods of Sauerbruch or Brauer (see p. 703) may be adopted. The lung must then be incised as in a case of abscess (see p. 724). It is very difficult to find a small foreign body through such an incision, and no easy task to discover a large one even if it be a hard substance, but many successful cases are recorded. If an abscess, whether bronchiectatic or not, be opened and the foreign body be missed, the abscess should be drained. I have known a large piece of iron expelled through such a wound long after the operation.

Supposing the apparatus for high-pressure or low-pressure operation be not available and the position of the foreign body be unknown, it is a reasonable thing to make an opening into the thorax large enough to admit one or more fingers, as much indeed of the hand as is necessary to explore the lung; or, if preferred, the same object may be obtained by turning aside a flap of rib and intercostal muscles. A pneumothorax of course results. If the incision be merely large enough to admit a finger the entrance of air can be kept within bounds; but if a larger opening be made the pneumothorax will be complete. The dangers of this have of course to be faced, as has often been done in the removal of tumours of the chest-wall, and it must be remembered that the result is seldom fatal. After the exploration, if nothing be found, or if it be decided to postpone the attempt to extract the foreign body to another occasion, the opening in the chest-wall may be carefully closed and the air might be extracted from the pleura by means of an aspirator. But even if the air were not extracted it would ultimately be absorbed, though the period of waiting involved would seriously delay any subsequent operation. My experience of explorations on these lines is very limited, but I suggest them as a method of arriving at the same result as is obtained by Sauerbruch and Brauer, though with more risk to the patient and less comfort to the surgeon.

OPERATION FOR ACTINOMYCOSIS OF THE LUNGS

Numerous fungi may attack the lungs, amongst which actinomycosis is the one most generally recognized. It appears that more or less typical cases of the disease may result from the attacks of different organisms. The surgical treatment adopted for actinomycosis is suitable for all forms of pulmonary mycosis.

The organism may enter the chest by the air-passages or by extension from the liver. In time its ravages extend to the pleura and the ribs, in which it quickly invades the cancellous structure far and wide; and ultimately it points on the skin. Vigorous internal treatment with iodide of potassium having been started at the earliest opportunity, the external parts, including the ribs, should be freely dealt with, the softened tissues being cut out or scraped and treated with pure carbolic acid. It must be seldom that the infiltrated lung can be attacked with any safety, as is shown by studying museum specimens; but the treatment here recommended, accompanied by the administration of 90 or 120 grains of iodide of potassium a day, may effect a cure even although the lung is considerably involved. If an attempt be made to scrape the lung, very free hæmorrhage must be anticipated and the unsatisfactory process of packing the wound in the lung will probably have to be reverted to.

Although speaking from a rather large experience of actinomycosis, I have never met with a case of infection by an aspergillus or any other fungus.

OPERATION FOR HYDATID DISEASE OF THE LUNG AND THORAX

Echinococcus cysts may occur in the bones of the chest. Such cases require treatment on general principles. They may also be met with in the mediastinum, the lung, and the pleura, which may be the primary seat of the disease or may have been invaded from the liver or some other abdominal viscus. They may be living, or dead and suppurating. The latter must be treated like abscesses of the mediastinum or lung, or like empyemata, as the case may be, the only difference being that the endocyst and all daughter cysts should be removed. The chance of removing the ectocyst is very small, but if it can be effected the cure will be more rapid.

Operation. In the case of a living hydatid, supposing the diagnosis to have been made, the surgeon should on no account explore the cyst even with an aspirator, because of the risk of rupture into a bronchus occurring at the same time, which may result in suffocation. After opening the chest very freely the cyst should be exposed, whether in the mediastinum, pleura, or lung, and after evacuating the contents, an attempt may be made to isolate it from surrounding structures. If this should prove successful the hole in the chest-wall may be closed; if unsuccessful, the cyst must be fixed to the opening and the tedious process of 'healing from the bottom' embarked upon. During this process the patient should be kept in good hygienic surroundings. I have seen more than one case become tuberculous. The expectoration of hydatid material does not prove the existence of an intrathoracic cyst, and should suggest a careful examination of the liver, as hydatids of this organ not infrequently burst upwards. Such cases are usually best dealt with by making an abdominal, or at all events a subdiaphragmatic, as well as a thoracic opening. Multiple hydatids of the chest, though not common, are by no means unknown.

OPERATION FOR DERMOIDS OF THE INTERIOR OF THE THORAX

Dermoid cysts of larger or smaller size are occasionally met with in the chest; they sometimes involve the pleura and usually the lung, but this does not prove that they do not always originate in the mediastinum. They resemble ovarian dermoids in being lined by real skin

and in having large finger-like processes springing from the inner wall, from which as well as from other parts long hairs, sometimes like those of the patient's head, sometimes of a different colour, grow. Occasionally bones and other fœtal débris are met with, suggesting the idea that they are included fœtuses. They need cause no symptoms until they burst into a bronchus, which seems sooner or later always to occur, or into the pleura, which is less common. In the latter case an empyema results, on opening which the diagnosis is made on

FIG. 373. DERMOID CYST OF THE MEDIASTINUM AFTER ELEVEN OPERATIONS. A, Lower limit of original incision; B, C, D, E, Pouches still remaining, lined by skin. That indicated by B communicates with a large bronchus.

finding free felted masses of hair in the interior. In such a case it is necessary to make a very free opening and remove as much as possible of the finger-like processes and skin, but the complete removal of the cyst is impossible as it actually involves the lung. The result is unsatisfactory because the interior does not dry up, however large the opening, and the offensive smell of decomposing epithelial structures is a great annoyance to the patient. Moreover, as a bronchial fistula is usually present, the disagreeable consequences of a discharge of mucus, more or less cough, and the chance of strange noises occurring at the external opening add to the patient's troubles. All that can be done

is to wear permanently a large vulcanite, or silver, or rubber tube, and keep the cavity as clean as possible.

The same must be said about those cases, usually situated near the middle line, which have ruptured into a bronchus, but in which the pleura has escaped. One or two small ones have been successfully removed, and an attempt should be made to enucleate such a one if it appears to be circumscribed; but numerous autopsies have shown that the deeper parts are usually so intimately related to the large vessels in the mediastinum that complete extirpation is quite out of the question.

It may be added that by free drainage the general health may be improved, amyloid degeneration counteracted, and life prolonged; and the patient is probably glad to substitute the discomfort of a rather odorous external wound for that of a racking cough with foul expectoration. I think the risk of hæmorrhage is rather increased by the operation. A case under my care at the present time has greatly benefited by operation. This has been repeated on many occasions. Each time more of the hairy skin has been removed or cauterized, until at last there is little more than a large bronchial fistula, the outer part of which is lined by skin (see Fig. 373). Considerable portions of the upper rib cartilages and ribs have been removed on the right side and the pulsation transmitted to this unprotected area has a somewhat alarming appearance.

REMOVAL OF TUMOURS OF THE LUNG AND MEDIASTINUM

There are primary simple tumours of the lung, such as fibromas, lipomas, and others, about which little is known and no surgical treatment is at present likely to be suggested.

Hitherto the available methods of diagnosis have seldom been sufficiently exact to warrant an exploratory incision while such growths are small enough to justify attempts at removal. Should radiography or physical signs render the presence of such a growth probable no hesitation should be felt in opening the chest, even without the means of preventing pneumothorax mentioned at p. 703, because the disease if left alone is hopeless, and the possibility of removing even large portions of the lung without fatal results has been fully demonstrated both in man and in the lower animals.

If in dealing with a malignant tumour of the chest-wall it be found to infiltrate the lung, the extent of the growth in this direction and if possible the state of the bronchial glands should be ascertained by palpation, and if it appears sufficiently circumscribed the whole mass should be removed together, either after constricting the lung beyond

it with ligatures or, if this be not done, by cutting it away with the actual cautery. Flaps of pleura may be fashioned to cover over the stump.

The mortality after these operations is likely to be high and the prognosis, even if they are successfully completed, unfavourable.

The method of opening the chest widely by making a large flap, including the superficial soft parts together with the ribs and pleura, might be found useful in exploring or dealing with primary tumours. After the removal of the portion of lung, or after deciding that this is not possible, the thoracic walls would be sutured carefully in position. Supposing the 'high-pressure' or 'low-pressure' methods were adopted the difference between the intrapleural and the extrapleural pressure should be maintained until not only the muscular and osseous flap, but also the skin flap have been accurately sutured. If the operation be done under ordinary atmospheric conditions the air may be, in part at least, extracted by the aspirator at the end of the operation. But this is of doubtful value and might well result in the displacement of a pleural flap or the sucking in of air through divided bronchi or pulmonary parenchyma. Moreover, if the case be aseptic the air will be absorbed.

The position of the opening into the chest must vary with the supposed position of the tumour, but for the purpose of exploration, if there be no certain guide from physical signs, the lower axilla is likely to yield the most satisfactory results.

REMOVAL OF TUMOURS OF THE MEDIASTINUM

I have not yet met with a tumour of the mediastinum, either simple or malignant, which seemed to me capable of removal, though I have endeavoured to do so after trephining the sternum. It has been recommended to trephine or resect parts of the sternum or to freely open the posterior mediastinum, but the prospect of dealing satisfactorily with malignant growths in this region seems to me very slight. Still, after reading of an operation by Dr. Marwedel,[1] for sarcoma of the mediastinum in a woman of twenty-two, in which, after removal of the manubrium and parts of the first and second right ribs and wounding the pleura, the tumour was successfully taken away, and not only did the patient recover but at the end of two years was alive and well, having married and borne a child in the meantime, it does not do to speak too disparagingly of this new field of surgical advance. The recorded cases show a high mortality and a high percentage of early recurrence, as might have been expected. Secondary tumours are beyond the reach of operation.

[1] Recorded by Amburger in *Beiträge zur klin. Chir.*, 1901.

CHAPTER V

OPERATIONS UPON THE PERICARDIUM, THE HEART, AND THE PULMONARY ARTERY.

THE REPAIR OF WOUNDS OF THE PERICARDIUM AND HEART

WOUNDS of the pericardium and heart may be produced by stabs, or bullet wounds, or injuries to the chest-wall with or without fracture of ribs or sternum, or by some quite unlikely agencies. The substance causing the wound may have entered from the front, or the back, or the side, or from above or below. A sword-swallower injured his heart in a misdirected effort, and the heart may be ruptured by a blow on the epigastrium. A man may be shot in the recumbent position, and the bullet has been known to enter the heart through one of the great vessels without passing through the pericardium. In the soft chests of children or women the heart may be almost separated from its attachments without any fracture or external wound (see Figs. 374–7).

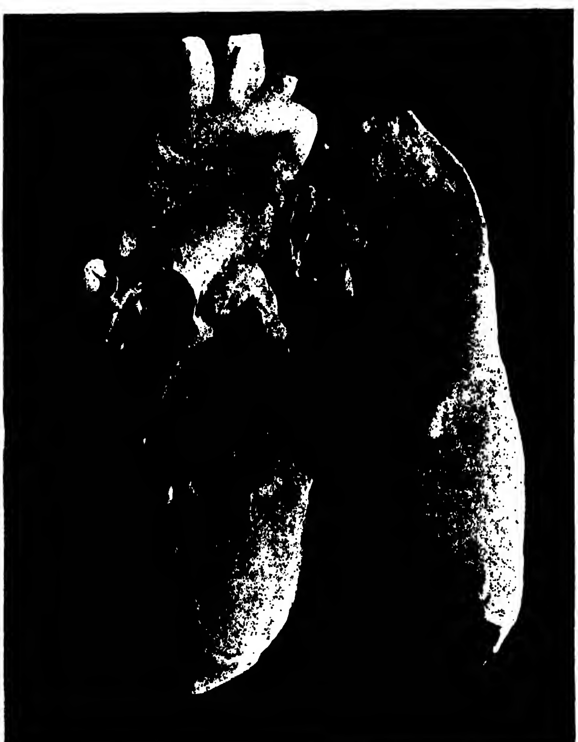


Fig. 374. A WOUND OF THE HEART WHICH PASSED THROUGH THE VENTRICULAR WALL WITHOUT ENTERING THE VENTRICLE. (*University College Hospital Museum.*)

Indications. When it is remembered that the injury may vary from the mere prick of a needle to the grave injuries just mentioned, it

will be recognized that the advisability of active surgical treatment must vary enormously with the nature of the case; in some the chance of recovery without interference being great, and in others the chance of doing good being nil. There are various other considerations which modify the prognosis and treatment; for example, wounds of the ventricles need not necessarily penetrate the cavities, those of the auricles practically always do so.

Fig. 375. An Extensive Rent in the Right Ventricle caused by a Crush. (*University College Hospital Museum.*)

Wounds of the septum need cause no hæmorrhage; injury of a coronary artery is a very serious complication, as is that of the peritoneum, while a less serious but more common one is the involvement of one or both pleuræ; but if the lung or a bronchus be injured, air may enter the pericardium and give rise to strange physical signs and symptoms. If there be an external wound there can be no security against sepsis, and as many promising cases have died of pericarditis and pleurisy, this must be borne in mind when the question of the closure of the wound is being considered. It does not follow, because there is free hæmorrhage from a stab in the cardiac region, that the bleeding comes from the heart, as it may come from an internal mammary or intercostal vessel. The blood coming from the right side of the heart is of course dark, that from the left bright.

Until about 1896 no attempts were made to deal surgically with wounds of the heart. They were all treated by absolute rest, low diet, and sometimes by blood-letting; and a certain number of cases recovered, as is shown by the records of many in which the diagnosis was almost above suspicion, and others in which foreign bodies have actually been found in the substance of the heart long after they have been known to have

entered it, such as bullets or needles which have penetrated from outside or which have been swallowed.

As this is the case, it may be right to pause in any given case of suspected heart injury before proceeding to an operation; but against waiting too long it may be urged that bleeding which has stopped not unfrequently recurs, that the patient's condition may be rendered so much worse by delay that surgical interference becomes hopeless, and that while, as has been said, foreign bodies in the heart sometimes do no harm, they may give rise to fatal consequences at a remote period after their introduction. It may be said that the operation in itself is a dangerous one, and this cannot be denied; but, on the other hand, the dangers of septic pericarditis ought with our present methods to be materially diminished by its performance. On the whole, therefore, modern opinion seems to be in favour of early interference in cases of suspected or undoubted injury to the heart.

FIG. 376. A WOUND OF THE HEART CAUSED BY A BLOW FROM THE FIST. (*St. Thomas's Hospital Museum.*)

Operation. As is common in new fields of surgery, a number of different methods of operating have been recommended, and in the lack of personal experience it becomes necessary to mention the general principles, and to select for more detailed description those which seem most wise.

The earlier operations appear to have been done through an opening obtained by the removal of one rib. I do not think this will generally give enough room for the subsequent procedures.

The other plans recommended consist either in (1) the removal of parts of two or more ribs and rib-cartilages subperiosteally, or (2) the formation of a hinged flap consisting of skin, ribs, and muscles, or (3) in the com-

bination with either of these methods of the section, or removal, of a portion of the sternum. To these I may add what does not appear to have been practised, (4) the reflection of a skin flap and then of a hinged flap of muscle and bone, and, lastly, (5) the exposure of the heart through an abdominal incision.

The exposure of the heart through an abdominal wound does not appear to be a practical procedure, and would probably only suggest itself in cases where such a wound is already present. It seems unlikely that a free view of the cardiac wound could be obtained in this way.

FIG. 377. WOUND OF THE HEART FOLLOWING A FALL. A needle has passed through an intercostal space and penetrated the apex of the right ventricle. (*St. Thomas's Hospital Museum.*)

The subperiosteal removal of the ribs is said to be unobjectionable because the ribs are regenerated. As so great a portion of what is removed is cartilage I doubt if this can be trusted to, and I do not think it is wise to leave the heart unprotected. Moreover, this is not the most expeditious way of operating.

The division of the sternum seems a needlessly severe procedure, and unless it were divided in two places it is difficult to see how the bone could be drawn aside.

It appears therefore that a hinged flap of ribs and intercostal muscles is most to be recommended. In descriptions of these operations the skin is usually left attached to the flap, but I cannot help thinking that it would be more easily done if the flap of skin and pectoralis major were first reflected, and then the flap of ribs and muscles; and that the suturing of the wound would also be more easily performed if this course were followed.

A horseshoe-shaped or rectangular flap is probably preferable to a triangular one. The base may be internal or external, or, if it be preferred, superior or inferior; but the most practical plan seems to be to turn the flap outwards. It should be at least 3 inches from side to side, and should extend almost or quite half-way across the sternum. It should be large

enough from above down to expose the fourth, fifth, and sixth ribs (see Figs. 378, 379). Supposing the flap of skin and pectoralis major be first turned aside, the flap of rib and muscle may be turned either inwards or outwards. The latter seems to be the better plan, as it admits of removing a part of the sternum, if necessary. The knife is carried along the upper border of the fourth rib and a short distance below the lower border of the sixth rib, the cartilages and muscles are then divided close to the sternum, and the

FIG. 378. DISSECTION TO ILLUSTRATE THE OPERATION FOR DEALING WITH WOUNDS OF THE HEART. P.M., Pectoralis major; S., Sternum; III, IV, V, VI, VII, Ribs and rib cartilages; I.M., Internal mammary vessels; T.S., Triangularis sterni; D., Diaphragm; PL., Pleura, the edge shown by dotted line; P., Pericardium.

ribs are cut through with cutting pliers 3 inches or more from the sternum. The flap is then raised and pulled forcibly outwards. The pleura, if not already wounded by the injury, is, if possible, preserved intact; but if it be opened, the margin of the lung must, either at this period or later, be sutured to the intercostal spaces. Should a pneumothorax occur, the consequent diminution of the blood pressure will facilitate the subsequent placing of the sutures in the heart, contraction of which will be rendered less forcible. It has indeed been actually recommended to make a pneumothorax with this object by opening the pleura. At this

period of the operation it will probably be necessary to ligature the internal mammary vessels in two places, and most likely to tie one or more intercostal vessels. The incision into the pericardium is best made in a vertical direction, but lateral incision may be added if necessary (see Fig. 379).

The real difficulties of the operation now begin. The blood or clots, or the mixture of blood and air, must be rapidly but gently removed from

FIG. 379. DISSECTION SHOWN IN FIG. 378 COMPLETED. P.M., Pectoralis major; S., Sternum; III, IV, V, VI, VII, Ribs and rib cartilages; I.M.A., Internal mammary artery; PL.R., Right pleura; PL.L., Left pleura; H., Heart.

the pericardium, and a search made for the wound. This is fortunately usually on the anterior surface. But it may be behind, or there may be more than one. It may involve either ventricle or auricle, or one of the large vessels, and it may be complicated by a wound of a coronary artery. The wound in the heart must be temporarily gently plugged, which is an easier matter in the case of a ventricle than in that of an auricle. In either case it may necessitate the gentle grasping of the heart with the surgeon's left hand. Great care should be taken to prevent the sucking of air into the heart. The stitches are then to be inserted. If trustworthy catgut be at hand, it is preferable to silk or linen thread; but

either may be used. Intercepted sutures are probably better than continuous ones; they may be introduced with a fully curved needle held in a needle-holder, and must be much closer together in the case of a wound of an auricle or large vessel than in that of a wound of a ventricle. Some surgeons recommend a purse-string suture.

During the insertion of the stitches the heart must be steadied, either by the surgeon's left hand or by the insertion of a silk thread through the apex of the heart. It has been recommended to pass stitches into the left ventricle during systole and into the right during diastole, but the physiological correctness of this advice has been called in question, and the practicability of carrying it out appears very doubtful.

When it is clear that the wound or wounds are completely closed, all hæmorrhage from the coronary arteries or their branches is to be attended to, and then the incision in the pleura is to be sutured. It appears to be safest to leave a drainage tube in the pericardium, because pericarditis frequently follows the operation. Some have also methodically drained the pleura if that cavity has been opened, but this may be left to a later occasion, as necessity for it may never arise. The accumulation of a certain amount of fluid in the pleura is not so serious a matter for a patient who is passing through this ordeal as is the presence of a serous or purulent collection in the pericardium. After suturing the pericardial wound the flap of ribs and muscles is to be replaced and fixed by a few sutures, and then the edges of the skin are to be brought into accurate apposition. In the course of the operation it may have been necessary to snip away a part of the sternum by means of gouge forceps or other suitable instruments, in which case the flap of ribs and muscles can only be secured in place at the upper and lower borders.

It is needless to say that during the performance of the operation the patient's condition is likely to be a very critical one, and that cases of death on the table must occasionally occur. The question of the administration of a general anæsthetic will have to be considered, and no doubt in a certain number of cases it can be dispensed with. If the pulse becomes extremely feeble, it may be advisable to give an injection of saline solution either into a vein or into the right side of the heart. But this should be done cautiously, lest the resulting increase in the force of the cardiac pulsations should interfere with the insertion of the stitches.

If the apparatus were at hand and time allowed, the use of the 'high-pressure' or the 'low-pressure' methods of operating might conceivably prove of great service.

In writing this section I am much indebted to Professor Riedinger's excellent chapter in the *Handbuch der praktischen Chirurgie*, 1907, p. 529.

PARACENTESIS AND OPENING OF THE PERICARDIUM

Paracentesis. In pericardial effusion where there are no adhesions, the heart occupies the outer, anterior, and upper part of the pericardium; the fluid collecting chiefly at the posterior and lower part of the cavity. This is the case when the body is recumbent as well as when it is erect. It is thus possible to aspirate the pericardium through an intercostal space near the lower part of the sternum without injuring the heart. But owing to the variation in the extent forwards attained by the pleura, there is no certainty that this sac will be avoided, even if the spot chosen be the fifth interspace on the left side close to the sternum. On the other hand, if a similar spot on the right side be selected, it is just possible that the pleura will escape. Some authorities state that a distended pericardium separates the two pleuræ, but I doubt if this is generally the case. Fig. 380 gives the arrangement of pleura, pericardium, and vessels as determined by the average of several dissections. It is not, however, usually a matter of much importance in performing simple aspiration, though, if the fluid be actively septic, the pleura may become infected.

The only way to be sure of escaping the pleura is to puncture from below with or without preliminary abdominal incision. The latter plan would probably avoid injury to the peritoneum. Another suggested route for entering the pericardium is by trephining the sternum. It is seldom followed, for it complicates the operation and does not necessarily secure the avoidance of the pleura, because, in the first place, the two pleuræ are often in contact much lower down than is considered normal, and, secondly, the line of attachment of the anterior mediastinum to the back of the sternum, which forms here a sort of mesopericardium, is easily moved for a considerable distance to one side or the other, and such displacement may well occur in a case of pericardial effusion. In selecting the spot for the puncture, the position of the internal mammary artery must be borne in mind. Though subject to a certain amount of variation it usually approaches closely to the border of the sternum, and is here almost never more than ½ inch from its outer border. The spot therefore to be recommended is the fifth left interspace, ¾ inch from the sternum. The trochar should be passed backwards and to the right. If the right fifth intercostal space be selected, the trochar should be passed backwards and to the left. A bottle aspirator with very slight negative pressure in the bottle, a siphon arrangement by means of a long india-rubber tube fixed to a trochar (see Fig. 362), or even a simple exploring trochar may be employed for the purpose. The ordinary perforated needle is not recommended.

Incision. If a free opening is to be made, it will probably be advisable to remove rather more than 1 inch of the fifth rib cartilage, and perhaps a small portion of the sternum. This depends upon the age, or rather the size of the patient. It is convenient but not essential to tie the internal mammary vessels. After cutting through the triangularis sterni, a careful look out for the pleura must be made, and if it be seen it should be turned aside. The amount of displacement of the pleura which may follow on pleurisy and chronic lung diseases is quite remarkable, one lung often reaching considerably beyond the opposite border of the sternum. If opened it is best to stitch up the opening in the pleura at once. The drainage tube should reach the posterior part of the cavity. The operation is conveniently done through a vertical or an oblique incision.

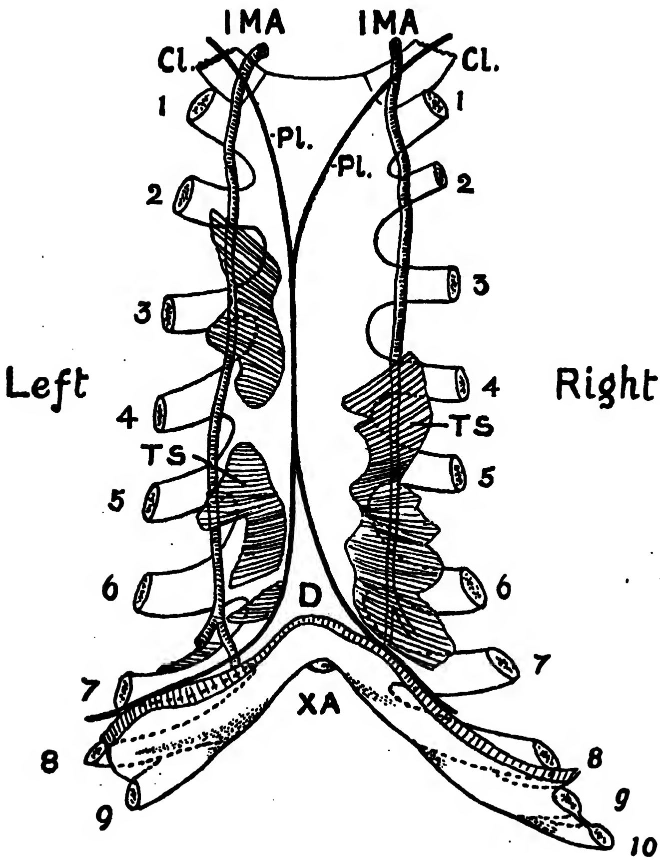


FIG. 380. PARTS IN CONTACT WITH THE STERNUM AND COSTAL CARTILAGES VIEWED FROM BEHIND. 1 to 10, Rib cartilages; CL., Clavicle; X.A., Xiphoid appendix; T.S., Triangularis sterni; D., Diaphragm; I.M.A., Internal mammary artery; PL., Pleura.

Pyopericardium may easily be mistaken for empyema. It may coexist either causally or accidentally with many other conditions, such as subdiaphragmatic abscess, liver abscess, or empyema. If the association be with empyema, the pericardial swelling may well escape notice until it is felt by the finger introduced into the pleura. Even then the condition has remained unrecognized, the swelling being mistaken for a consolidated lobe of

the lung. If a correct diagnosis be made, the proper thing is to incise the pericardium through the pleura. Cases have been recorded in which this course has been followed by cure. It must be remembered that pyopericardium, like empyema, may burst into a bronchus.

CARDIOLYSIS

Cardiolysis is the name given to an operation first suggested by Brauer in 1902 (*Archiv für klin. Chirurgie*, von Langenbeck, 1903, p. 258), intended to counteract the mischief which results from adhesive mediastino-pericarditis, that is, pericardial adhesions accompanied by adhesion of the pericardium to the chest-wall. The object is to prevent the extra work entailed on the heart owing to its inability to retract the rigid chest-walls, as it can the soft parts under normal conditions.

It consists in the removal of 3 or 4 inches of the fourth and fifth ribs and rib cartilages, and, if necessary, also of portions of the third and sixth ribs or rib cartilages and a piece of the left border of the sternum.

The operation is a simple one. A horseshoe-shaped flap of suitable width, hinged upwards and with the inner side over the left border of the sternum, has been recommended. It should contain all the structures superficial to the ribs. I think it would be better, as involving less injury to muscle, if the flap were hinged outwards; or if the skin and fat were reflected in any direction preferred and the muscle subsequently turned outwards.

The ribs and cartilages are then removed with the superficial periosteum and perichondrium; but it is safest to strip these membranes from the deep aspect of the ribs and cartilages before dividing them, as otherwise the pleura is likely to be opened, and this would, under the circumstances, be an undesirable complication.

The object of removing as much of the periosteum as possible is to prevent the re-formation of the ribs and a consequent recurrence of the mischief. If there be time the attempt might be made carefully to dissect away the deep layer of the periosteum after the removal of the ribs; but it is not easy in so doing not to injure the pleura. No attempt should be made to do this with the perichondrium, as it is not likely that either bone or cartilage would be formed from it if it were left.

The operation is completed by replacing and suturing the flaps.

It is thus seen that the name implies more than the operation effects, as no attempt is usually made to deal with any adhesions except those of the pericardium to the chest-wall. To try to separate the intrapericardial adhesions would be dangerous and probably ineffectual, and is moreover unnecessary.

Any needless removal of bone should be avoided, as it is not desirable to uncover the heart unnecessarily.

After recovery a suitable shield or protection must be worn.

REMOVAL OF CLOTS FROM THE PULMONARY ARTERY

Trendelenburg has shown (*Zentralblatt für Chirurgie*, January 25, 1908) by experiments on animals that an operation with this object can be successfully carried out, and at the meeting of the Deutsche Gesellschaft für Chirurgie, 1908 (*Zentralblatt für Chirurgie*, No. 35, 1908), three operations on the human subject were reported, and though all ended fatally, one during the operation, one fifteen hours after the operation from heart failure, and one thirty-seven hours after the operation from hæmorrhage from the internal mammary artery, it is evident that the matter is one for serious consideration. In support of this statement Trendelenburg points out that sudden death after the occurrence of the embolism is the exception, that at least half the cases survive for fifteen minutes, and that some live for an hour.

He recommends in the later of the two publications the formation of two triangular flaps (see Fig. 381) beneath the left clavicle by means of two incisions: one carried vertically along the left border of the sternum from the lower border of the first rib to the upper border of the third, and a second transversely along the second rib for 10–12 centimetres. A portion of the second rib about 10–12 centimetres long is then either resected or divided at the outer part of the wound and raised and bent forcibly to the right over the sternum. If more room be required, a portion of the third rib must be taken away. The pleura is then opened, and the pericardium is cautiously incised, after picking it up with two pairs of forceps, to the inner side of the phrenic nerve, which must be carefully avoided. The incision must be enlarged upwards and backwards until the upper half of the pericardium is opened; the lower half is not interfered with, and the heart itself is not displaced. The two flaps of pericardium are then drawn apart against the sides of the wound in the chest-wall either with hooks or by means of sutures. The pulmonary artery and the aorta, which is closely adherent to it, are now seen, and a hook-shaped (*hakenförmig*) olive-pointed sound of about the size and length of a middle-sized catheter is passed with a rotatory movement into the sinus pericardii transversus, behind both the aorta and pulmonary artery, until its point appears near the edge of the sternum. This, with proper management, is said to be an easy performance. The sinus readily admits the index-finger, which may be employed to assist the passage of the sound if it does not pass easily.

The sound is then pressed somewhat forwards in order to draw the vessels forward and to steady them, and later on it is pressed more forcibly forwards, while the artery is compressed against it by means of the finger. The sound will lie opposite the pulmonary valves.

Before making pressure the visceral pericardium and the underlying fat should be stripped off the pulmonary artery with two pairs of forceps, in order to ensure a good view of the spot (not too near the valves) where

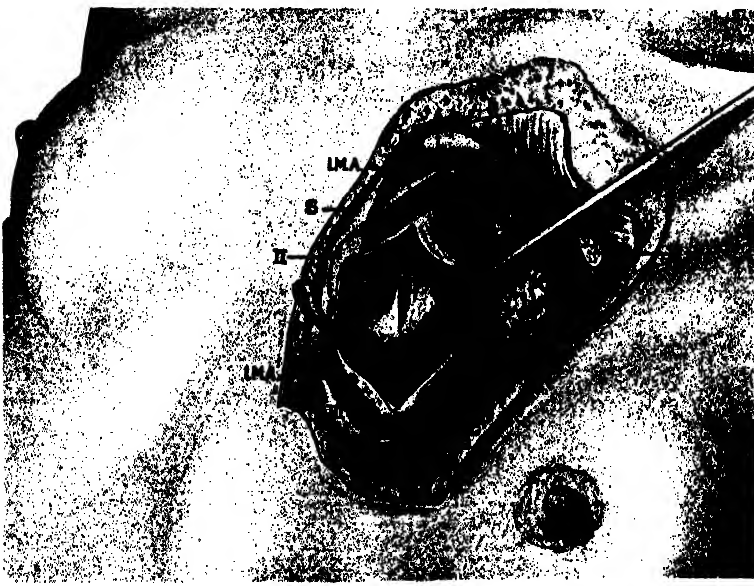


FIG. 381. DISSECTION TO EXPLAIN TRENDELENBURG'S OPERATION FOR REMOVING CLOTS FROM THE PULMONARY ARTERY. P.M., Pectoralis major; S., Sternum; I, II, III, Rib cartilages (and divided second rib); I.M.A., Internal mammary artery; P., Pericardium; A., Aorta; P.A., Pulmonary artery; P.L., Pleura; L., Lung.

the artery is to be incised and to facilitate the subsequent insertion of the sutures.

Compression is now made, the artery is incised, a pair of bent polypus forceps is inserted and passed into the main trunks, or, if necessary, into the branches of the vessel, and the clot, if it can be seized, is extracted. The forceps may be introduced to a depth of 6 to 8 centimetres. Without loss of time the wound in the artery is closed by means of a curved clamp placed parallel to the long axis of the artery, so that the edges of the wound project a few millimetres beyond its blades. The compressing finger is raised and the sound is removed; the blood flows again through the pulmonary artery, and is prevented from escaping by the clamp.

The stitches can now be introduced at leisure. The application of the clamp is facilitated by the use of a pair of weak-springed forceps with the points turned outwards into hooks. The forceps are introduced closed into the wound in the artery, the hooks catch under the two ends of the incision, stretch it, and pull the edges of the wound forwards into the grasp of the clamp.

A few stitches placed in the pericardium and the closure of the opening in the chest-wall complete the operation. Experience will show whether polypus forceps or some other instrument is more efficacious for removing the clots.

It is needless to say that such an operation is not likely to be available in many cases. It must in fact be almost necessarily confined to hospital practice, and indeed to the practice of hospitals possessing a resident surgeon of sufficient responsibility to entrust with such a serious diagnosis and operation. Experiments on animals showed that complete compression of the artery could only be maintained with safety from 45 seconds to 2 minutes. Trendelenburg considers 45 seconds sufficient time for two such 'simple proceedings as incising the artery and extracting the clots', but he points out that, if more time is required, it may be obtained by temporarily clamping the wound in the artery. Fifteen minutes, he thinks, allows time enough for the completion of the operation in a hospital, or, at all events, for reaching the critical stage of it.

CHAPTER VI

OPERATIONS UPON THE DIAPHRAGM AND FOR SUB DIAPHRAGMATIC AND HEPATIC ABSCESS

REPAIR OF INJURIES OF THE DIAPHRAGM

THESE may result from simple compression of the body without external wound, or from penetrating wounds of the thorax or abdomen, or conceivably from objects passed down the œsophagus. They are often accompanied by the formation of a diaphragmatic hernia in which small portions of one or more viscera or large quantities of the abdominal viscera may find their way into one or other pleural cavity or into the pericardium. The right half of the diaphragm has been ruptured more often than the left. More or less definite and typical physical signs and symptoms may result, but the nature of the injury may escape notice. If the rent be small and occupied by a portion of intestine, strangulation with its characteristic symptoms may set in.

Indications. Healing has in some cases undoubtedly occurred; in others the aperture has remained permanently open, with consequent inconvenience and perhaps risk to the patient. It is better, therefore, to endeavour to close it.

Operation. If there be already an abdominal wound or a thoracic wound the surgeon will probably be inclined to make use of it, enlarging it if necessary for applying his sutures; but it is at least questionable whether he should not always supplement an abdominal wound by a thoracic, or a thoracic by an abdominal wound. It appears to be the experience of those who have had such cases to deal with that the insertion of the sutures is thereby much facilitated. In making the supplementary thoracic wound some have simply made an opening through an intercostal space, but I should think it would generally be best to make a hinged flap of ribs and muscles of fair size, and at the end of the operation to secure it in position. The question of the production of a pneumothorax does not enter into consideration; it must always be produced, unless the rupture has taken place at a part where pleural adhesions exist, in which case the diagnosis will probably not be made and the thought of an operation will, therefore, not occur. The position of the openings will be determined by the seat of the rupture.

In doubtful cases without external wound, if there be localizing signs pointing to either side, the linea semilunaris of that side may be sutured; but, if there be no such signs, a median incision is to be recommended.

OPERATION FOR SUBDIAPHRAGMATIC ABSCESS

Much has been written upon this subject. It may even be feared that over-refinement of classification and description may lead to confusion of thought and make the question appear more complicated than it really is.

Some general observations are called for before describing the comparatively simple operative procedures that may be required.

The diagnosis is often difficult. If the abscess be small and situated at the upper part of the dome of the diaphragm, it may produce no perceptible physical signs. If it be nearer the origin of the muscle, a subdiaphragmatic abscess is likely to be mistaken for some intrapleural affection. And even supposing there be no doubt of the situation of the disease, it is easy to mistake a new growth or an enlarged or displaced viscus for an abscess. A recognition of these difficulties and of the fact that delay is often very harmful should prevent the surgeon from postponing his investigations in cases of reasonable suspicion.

There are certain anatomical structures which may limit the extent of subdiaphragmatic abscesses. They are the right and left lateral ligaments and the falciform ligament of the liver, the small omentum, and in a manner of speaking, it may be said, the boundaries of the lesser sac of the omentum. But besides these normal barriers, abscesses beneath the diaphragm, being always associated with peritonitis, are usually surrounded by more or less firm peritoneal adhesions. It is in my experience not uncommon to find these adhesions limited by the margin of the chest-wall. The practical bearing of this observation is that, supposing in a case of doubt—say, in one of an abscess resulting from the gradual rupture of an ulcer on the anterior surface of the stomach near the small curvature—it be found that adhesions exist as far as the costal margin, the safest plan is to close the laparotomy wound and to attack the abscess through the attachment of the diaphragm, but of course below the limits of the pleura. A clear appreciation of these natural and adventitious limitations is of the utmost importance in the search for and the drainage of subdiaphragmatic abscesses.

The difficulties of diagnosis being recognized, it is essential to remember that a subdiaphragmatic abscess may result from many different causes, and that the nature of the contents and the gravity of the case, and the danger of delay in operating, are also subject to very considerable variation. It must not be forgotten that, while strictly localized abscesses

are most commonly associated with diseases of the viscera which lie in contact with the under surface of the diaphragm, that is to say, the stomach or duodenum, liver or kidneys, there is no abdominal viscus disease of which may not give rise to one; and that general septic peritonitis, if it does not prove rapidly fatal, is more often than not followed by more or less limited collections of pus round the back of the liver on the right side or round the spleen on the left. It is quite common, for example, if an inflamed appendix lies on the outer side of the cæcum, for the resulting abscess to track up along the ascending colon and form a collection far back between the liver and the diaphragm. I have known such an abscess burst into the lung. It should be a routine practice, therefore, if an appendix abscess occupies this situation, to explore its upper limits carefully and probably to drain it through a counter-opening in the loin. I have seen recently an abscess between the front of the liver and the diaphragm reaching up to the fourth rib, starting from a long gangrenous appendix that reached up behind the ascending colon as far as the hepatic flexure. In cases of general septic peritonitis it should also be as much a routine practice to explore and sponge out both the post-hepatic and the splenic regions, as it is to investigate the pelvis; and if some time after the primary operation the case should not progress favourably, particular attention should be devoted to these regions; and should there be any suspicious symptoms or signs, I would almost say even if they be not present, an exploration which if it does no good is not likely to do harm is more than justifiable; for during the period of doubt and delay the patient's strength is probably being reduced by septic absorption and fever. I have known this to be continued until the shock produced by the operation, when it did take place, was too great for the patient's enfeebled powers of resistance.

It has been hinted that the pus from a subdiaphragmatic abscess is at least as variable as the viscus from which it has originated. Thus, while it may be simple odourless pus, it may be pus mixed with stomach or intestinal contents, bile, urine, hydatid cysts, and so forth, or it may be the chocolate-coloured pus derived from an abscess of the liver. But from the present point of view the important point to remember is that these abscesses often contain gas. If this be the case, a mistake in diagnosis may easily be made, and if it be discovered at the operation the suggestion is obvious that the abscess has originated in a rupture of one of the hollow viscera. This conclusion is, however, not absolutely a certain one, as bacterium coli and other organisms may cause the development of gas. Such abscesses as these may reach an enormous size and hardly merit the name of subdiaphragmatic abscesses. I have known a ruptured duodenal ulcer result in an enormous cavity,

yielding tympanitic resonance and a typical bell sound from the third rib on the right side to Poupart's ligament when the patient was recumbent. The resonance and dullness of course change places on assuming a different posture. It is to these abscesses that the rather ridiculous though descriptive name of subdiaphragmatic pneumothorax has been applied. It is especially, though not exclusively, in these cases that displacement of the heart (mediastinum) either laterally or vertically may take place.

Operation. With regard to treatment there are certain main rules for our guidance. The objects are to open the abscess safely, to drain it efficiently, and, if it involves no extra risk to the patient, to deal at the same time with the source of the mischief. It is useless to say that a subdiaphragmatic abscess should be opened behind close to the lower margin of the ribs, which is the most favourable position for drainage in many cases, because a considerable number could not be safely reached from this position. Each case must be considered from its own special point of view. My meaning can be best illustrated by a few actual examples.

A young woman with signs suggesting left empyema, but a history pointing to ulcer of the stomach, was explored with the aspirator through the dull area in the back. Stinking pus was reached, but it was found that the pleura contained a small quantity of clear odourless fluid. An exploratory opening below the costal margin revealed the presence of adhesions between the liver and stomach and the stomach and diaphragm reaching as far as the costal margin. The opening was therefore closed and a spot was selected in the mid-axillary line below the normal limit of the pleura. Through this incision a portion of rib was removed; the origin of the diaphragm was then cut through and the finger passed through the adhesions along the anterior border of the spleen until the abscess was reached. This was a safe and successful operation. Any attempt to deal with the ulcer would have been useless and unjustifiable. But supposing the first incision had led into adhesions, or the abscess itself and the ulcer had been on the lower instead of the upper part of the anterior surface of the stomach, it would have been proper to deal with them at once. Supposing, on the other hand, it had been found that the front of the stomach was normal, it would probably have been necessary to go further back and make a transpleural operation, following the rules laid down at p. 753.

A man with a ruptured duodenal ulcer—at all events this was the diagnosis—was the subject of such an enormous collection of pus and gas and intestinal contents as has been referred to at p. 749. On opening it in front below the costal margin the posterior wall of the abscess was

seen to consist of the intestines matted together by thick lymph. The simple insertion of a drainage tube was sufficient to cure this case, which happened many years ago. At the present time, no doubt, at least three incisions would be used, one in front, one below, and one behind. But the successful result in this case should remind us that it is not essential to disturb the adherent viscera in order to make a stab wound in the loin, though no doubt it is a good thing to make one if possible. The fact that no attempt was made to deal with the duodenal ulcer is also of importance. I am confident that any thought of a gastro-enterostomy should in such cases be postponed till after convalescence.

A young woman, previously in perfect health, suddenly began to pass hydatid cysts from the bowel, and later on to expectorate stinking pus containing similar material. An exploratory laparotomy showed that the parent cyst was at the upper part of the right lobe and of course firmly adherent. The laparotomy wound was closed and a posterior transpleural opening was made into the abscess, which ultimately closed after a secondary pulmonary abscess had been opened. Supposing the parent cyst had been low down on the anterior surface of the liver, it would have been necessary to fix it to the margins of the laparotomy wound and drain it in that way. I have not referred to the attachments of the colon to the under surface of the liver, which in this case I think it would have been perilous to disturb.

The liver of a man with a tropical hepatic abscess reached below the umbilicus; but on opening the abscess in what I consider the most favourable position (see p. 753) it was found that three pints of pus were present between the diaphragm and the liver, which indeed was not materially enlarged. A careful search was made with the finger and a probe over the upper surface of the organ, but the opening into the original abscess could not be found. So no more was done and recovery was rapid. If the opening had been met with, it would have been enlarged and the tube would have been passed into it; but knowing how quickly some hepatic abscesses shrink, it would, I think, have been bad practice to explore the liver further at the time.

The risks involved in delay may be illustrated by the case of a child who had a right anterior subdiaphragmatic abscess, as well as general peritonitis resulting from a long gangrenous appendix which lay behind the ascending colon. The operation consisted in removing the appendix, which involved pulling almost all the small intestines out of the long incision in the right linea semilunaris. The abscess was then drained through a stab wound in the loin and a tube was left in the lower part of the anterior incision. After some days of favourable progress the temperature became hectic and indefinite physical signs appeared at the

left base. These were watched from day to day, and at last a copious expectoration of stinking pus occurred which put the patient's life in some jeopardy. I think the right practice would have been to make an exploratory incision far back on the left side as soon as suspicion was aroused as to the existence of what is a common sequence of general septic peritonitis. It is at least possible that the damaged lung will some day require surgical treatment.

To sum up, it is advisable in a case of subdiaphragmatic abscess to open early, and if possible to avoid breaking down the adhesions that separate it from the general peritoneal cavity. It is best to make the opening behind; but this is not essential, and it must not be forgotten that during the after-treatment it is not essential to keep the patient on his back, and that by sitting him up or otherwise changing his position we may make even an anterior opening the most dependent possible. Lastly, if the primary cause of the mischief be not dealt with at the time it will often heal spontaneously, and in most cases is most safely dealt with at a subsequent period.

OPERATION FOR ABSCESS OF THE LIVER

Indications. Multiple abscesses and pylephlebitis and some other so-called abscesses are unsuited for operation; but if it be decided to operate the methods of procedure are the same whatever may be the cause of the abscess. One point must, however, be dwelt upon, *viz.* that rupture may occur into any of the viscera or the spaces or cavities which are in near relation to the liver, *e.g.* the peritoneum, forming either a localized subdiaphragmatic abscess (right or left), or into the general cavity of the peritoneum, or into the stomach, duodenum, colon or kidney, or into the pleura (right or left) or the pericardium, the lung (right or left), or the mediastinum. Although many cases have recovered without operation which have thus ruptured into lung, stomach, or bowel, it is bad practice to wait for such an event, the serious complications which may occur far outweighing the slight and problematical advantages of a spontaneous cure. Should rupture into lung, stomach, or bowel have occurred, it is right to wait a few days, but not longer, in order to see whether the exit for the pus seems to be sufficient; but, if all symptoms do not rapidly subside, an external opening should be provided without delay.

Operation. Sometimes the pointing of the abscess determines the spot at which the external opening is to be made, and in this case there is nothing more to be said about the operation except that the abscess must be opened, and the further remark which applies to all free

incisions into liver abscesses, *viz.* that the finger should be introduced and pockets and imperfectly opened diverticula should be explored and freely opened. The very thick pus usually met with demands a very large drainage tube.

If there be no sign of pointing, the seat of election for the incision is, in my opinion, at the side, midway between two lines prolonging downwards the anterior and posterior folds of the axilla, and this is the place for making the exploratory punctures with pretty large aspirator needles, 6 inches long, which, if the pus be not hit off at first, must be freely passed in all safe directions, the surgeon being guided by his anatomical knowledge. This position is selected because in this situation the highest possible opening can be made which does not involve interference with the pleura. The higher the opening, the better the drainage, as the liver always contracts upwards in the course of cicatrization. In this situation the interval between the margin of the ribs and the lower border of the pleura is, as a rule, at least 2 inches. A transverse incision about 2 inches from the costal margin is made on to the subjacent rib, a portion of which, 2 inches long, is then cleared from the periosteum and removed at the anterior part, the section probably passing through the cartilage. If the pleura be seen it is turned upwards out of the way. The diaphragm is then divided vertically, *i.e.* in the direction of its fibres, and the liver is exposed. If adhesions be present it only remains to open the abscess, which may conveniently be done by means of dressing forceps instead of a knife, especially if the pus be far from the surface. If bleeding be, as is sometimes the case, severe, the finger or a plug should be kept for a minute or two in the wound, after which time it will probably cease.

If there be no adhesions two courses are open to the surgeon: one the difficult one of stitching the liver to the diaphragm, and the other the simple one of packing off the peritoneal cavity with sterilized or antiseptic gauze before making the incision. I used formerly to practise the former method, but in recent years have adopted the latter, which appears to afford a satisfactory protection against peritonitis. It is of course not possible to be sure that the pus will not contain virulent septic organisms, but this is not usually the case.

Sometimes the abscess is at the back and can only be reached satisfactorily by a posterior incision. In this case the operation must pass through the pleura. I have read accounts of cases where no care was taken to occlude this opening in the pleura and where no harm came of it; but I have myself seen most disastrous results. I therefore am strongly of opinion that the pleural opening should be closed before opening the abscess. This may be done by making a rather free transverse

incision into the diaphragm and by passing a strong catgut continuous stitch right through its substance and through the structures occupying the intercostal space, *viz.* the intercostal muscles and pleura. Those who possess the means of operating with the 'Oberdruck or Unterdruck' apparatus (see p. 703) would no doubt find the operation much simplified by the avoidance of pneumothorax. No special instructions are required for the treatment of abscesses of the left lobe, except that preliminary exploration with an aspirator needle is not admissible in these parts of the liver.

Perhaps the most important point to bear in mind in treating abscess of the liver is to have sufficiently large and long tubes at first, not to shorten them too soon or to remove them until the discharge is practically nil. I believe many cases in which a second abscess is supposed to have been opened are really examples of refilling of the original abscess owing to the rapid shortening and removal of the tubes.

Other methods of opening and draining abscesses of the liver have been devised and are highly spoken of. One of the best is that suggested by Sir Patrick Manson. After puncturing the skin a large trochar and canula is thrust through all intervening structures into the abscess. After withdrawing the trochar a drainage tube of considerable size, which is tightly stretched on a strong probe, is then passed through the canula into the abscess; the canula is then withdrawn and the probe removed. The tube then becomes shorter but of wider bore, and tightly fits the track made by the canula and trochar. In this way it is stated that all risk of extravasation of pus into the pleura or peritoneum is effectually avoided. It must be owned that the device is simple and ingenious, and the objections that the tube can only be of a moderate size, that it is impossible to explore and break down septa in the cavity, and that it has been called a somewhat unsurgical procedure may be more apparent than real.

Like others, I have met with many cases in which the symptoms have appeared to point almost unmistakably to abscess of the liver, but in which recovery has taken place after exploratory puncture. This result, if it be a result and not a coincidence, has been supposed to depend upon local phlebotomy of the organ. In this connexion reference must be made to the remarkable results obtained by Leonard Rogers (see *Indian Medical Gazette*, April, 1908, and preceding numbers) from the administration of large doses of ipecacuanha in the preabscess stage of dysenteric (amœbic ?) hepatitis, and to observe that, as far as symptoms are concerned, it is impossible to say when this stage is passed. Rogers modestly says that this is only the revival of an old treatment. He also has employed 'aspiration and injection of quinine to kill the

amœbæ without drainage (which has proved a rapid means of curing some cases of small deep-seated abscess which are most difficult to open and drain)'. I have had no opportunity of trying this method of treatment with quinine, but I have seen the internal administration of ipecacuanha rapidly change the appearance of a sloughing amœbic abscess. I have tried the local application of ipecacuanha without any apparent result, and am therefore rather surprised to hear that the injection of quinine is efficient in destroying the amœbæ, seeing that they must exist in the liver outside the abscess cavity, where the drug cannot possibly reach them. After perusing Rogers's observations I should certainly combine the two treatments, or at all events should not inject the quinine without at the same time administering the ipecacuanha.

INDEX